

**Rehabilitation of the Anderson Memorial Bridge  
Bridge No. B-16-011=C-01-007  
North Harvard Street over Charles River  
Boston - Cambridge  
MassDOT Project No. 605517**

# **Bike and Pedestrian Underpass Feasibility Study**

**Prepared for:**



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***Bike and Pedestrian Underpass Feasibility Study***

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**1.0 INTRODUCTION****1.1 General**

The Anderson Memorial Bridge Rehabilitation Project is part of the Commonwealth's Accelerated Bridge Program. The Massachusetts Department of Transportation Highway Division (MassDOT) has hired the consulting firm of Fay, Spofford & Thorndike (FST) to study the feasibility of constructing a pedestrian/bicycle underpass through the existing bridge approach walls and a boardwalk pedestrian/bicycle underpass of the outer bridge arches.

**1.2 Scope of the Study**

The scope of the Underpass Feasibility Study is to assess the following:

1. The feasibility of constructing pedestrian/bicycle underpasses through the Anderson Memorial Bridge approach walls and outer tunnels.
2. Determine the impact that the addition of underpasses will have on the proposed project schedule.
3. Develop an estimated cost to construct the pedestrian/bicycle underpasses.
4. Determine whether or not the proposed Anderson Memorial Bridge Rehabilitation Project (if constructed without underpasses) precludes the ability to build underpasses in the future.

The proposed scope for the Rehabilitation of the Anderson Memorial Bridge was used as a baseline for assessing cost and schedule impacts associated with construction of the underpasses. The currently proposed rehabilitation scope for the structurally deficient Anderson Memorial Bridge includes the following major items:

- Retain and rehabilitate the existing concrete arches;
- Excavate to expose the top side of the arches, repair the concrete and replace the waterproofing;
- Complete replacement of the existing parapets, spandrel walls and brick arch rings along the fascias of the arches and;
- Complete replacement of the approach walls at both approaches and the northwest stairway.

**1.3 Existing Bridge Description**

The Anderson Memorial Bridge is a three-span concrete arch that carries



***Bike and Pedestrian Underpass Feasibility Study***

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North Harvard Street over the Charles River in Boston and Cambridge. The bridge measures 232 feet between abutments and has an overall length of 410 feet, inclusive of the retained fill approaches. The arches are supported by abutments and piers that are comprised of massive concrete footings founded on tightly spaced timber piles. The approach walls are unreinforced concrete gravity walls that are founded on timber piles on the Cambridge side and spread footings on the Boston side.

This historic bridge was built in 1915 and is an integral component of the Charles River Basin Historic District (Historic District), which is listed on the State and National Registers of Historic Places.

## **2.0 Feasibility Assessment**

### **2.1 Alternatives**

The following are the key factors that were considered in assessing the feasibility, cost and schedule impacts associated with the addition of underpasses to the Anderson Memorial Bridge rehabilitation project.

- Structural Impact on the Bridge
- Civil Alignment and Profile of the Underpasses
- Right-of-Way
- Utility Impacts
- Environmental Permitting
- Effects on Cultural Resources

Several underpass/boardwalk concepts were developed. The conceptual underpass/pathway designs include a minimum vertical clearance of 8 feet and a clear width of 16 feet, in accordance with the AASHTO requirements and MassDOT guidelines. The profiles and grades along the path were set based on a maximum 5% nominal grade, in accordance with the requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). The nominal grade of 5% can be refined to 4.5% during design as recommended by MassDOT to allow for construction tolerances.

The alignments were developed to tie the underpasses back into to the Charles River Reservation trail system and the existing sidewalks on Soldiers Field Road and Memorial Drive.

The following is a description of the underpass/boardwalk concepts that were evaluated.

***Bike and Pedestrian Underpass Feasibility Study***

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**Alternative 1A****Underpass on Cambridge Approach with Relocated Water Mains**

This alternative would include a concrete underpass through the Cambridge approach walls (see Figures 1, 2, 11 and 12). The underpass would be located a minimum of 10 feet behind the back face of the existing bridge abutment to facilitate rerouting of two existing 36" water mains on the bridge. This alternative also would require the reconfiguration or elimination of the existing stairway located at the northwest approach wall which would have an adverse effect on the historical integrity of the bridge and Historic District.

By rerouting the water mains, the profile of the underpass could be raised such that the top of the floor slab would be maintained approximately 2.6 feet above the normal water level of the Charles River, observed at elevation 1.3 feet (NAVD88). However, the profile would require construction of wingwalls and retaining walls outside the limits of the bridge and near the Weld Boathouse, which would have an adverse effect on the Historic District.

**Alternative 1B****Underpass on Cambridge Approach Located Below Water Mains**

This alternative would include a concrete underpass through the Cambridge approach walls (see Figures 3, 4, 13 and 14). The underpass would be located an estimated 4 feet behind the back face of the existing bridge abutment and would be located beneath the two existing water mains. This alternative would also impact the stairway located at the northwest approach, which would have an adverse effect on the historical integrity of the bridge and Historic District.

By lowering the profile of the underpass such that the existing water mains could be maintained, the underpass and pathways would be approximately 2.4 feet below the normal water level of the Charles River. In addition, the lower profile would require construction of wingwalls and retaining walls outside the limits of the bridge and near the Weld Boathouse, which would have an adverse effect on the Historic District.

**Alternative 2****Boardwalk Under the Exterior Arch (Cambridge)**

In lieu of providing a concrete underpass through the approach walls, we investigated using a boardwalk (see Figures 5 and 15) similar to what was done at the Boston University Bridge. This alternative would include a timber boardwalk structure that extends out into the Charles River and beneath the exterior arch. The boardwalk would include a walkway clear width of 12 feet, and

***Bike and Pedestrian Underpass Feasibility Study***

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42-inch high railings. The profile would be set based on maintaining an 8-foot minimum vertical clearance to the underside of the arch.

The vertical clearance requirement, coupled with the low profile of the arches would result in the boardwalk being located approximately 15 feet from the face of the abutment. This would reduce the clear channel opening at the exterior span from 65'-4" to approximately 37'. This would have a negative impact on the hydraulic opening, boat navigation, and rowing usage at the side channels of the bridge and would most likely have an adverse effect on the integrity of the Historic District.

**Alternative 3A****Underpass on Boston Approach with Relocated Water Mains**

This alternative would include a concrete underpass through the Boston approach walls (see Figures 6, 7 and 16). The underpass would be located a minimum of 10 feet behind the back face of the existing bridge abutment to facilitate the rerouting of the two existing water mains (36" with concrete encasement).

By rerouting the water mains, the profile of the underpass could be raised such that underpass/pathway could be maintained approximately 3.2 feet above the normal water level for the Charles River. However, the profile would require construction of wingwalls and retaining walls outside the limits of the bridge, which would have an adverse effect on the historic integrity of the bridge and the Historic District.

**Alternative 3B****Underpass on Boston Approach Located Below Water Mains**

This alternative includes a concrete underpass through the Boston approach walls (see Figures 8, 9 and 17). The underpass would be located an estimated 4 feet behind the back face of the existing abutment and beneath the two existing water mains.

By lowering the profile of the underpass such that the existing water mains could be maintained, the underpass and pathways would be approximately 1.0 foot below the normal water level for the Charles River. This would require construction of wingwalls and retaining walls outside the limits of the bridge, which would have an adverse effect on the historic integrity of the bridge and the Historic District.

***Bike and Pedestrian Underpass Feasibility Study***

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**Alternative 4****Boardwalk Under the Exterior Arch (Boston)**

Similar to Alternative 2 (Boardwalk on the Cambridge side), we developed an alternative for a timber boardwalk on the Boston approach (see Figure 10 and 15). The geometrics would be the same on both exterior arches and both boardwalks would need to be located 15 feet off the face of the abutment. Similarly, the resultant clear channel opening at the exterior span would be reduced from 65'-4" to approximately 37'. This would have a negative impact on the hydraulic opening, boat navigation, and rowing usage at the side channels of the bridge. Furthermore, this alternative will require construction of retaining walls outside the limits of the bridge, which would most likely have an adverse effect on the integrity of the Historic District.

The impact on the boating community would be magnified if a boardwalks were installed under both exterior arches. Following the December 2009 informational meeting for the project, the rowing community highlighted the importance of maintaining water clearance at all three barrels at the Anderson Memorial Bridge as well as their safety concerns related to boating activity in and around the bridge. It is highly likely that pursuit of the boardwalk alternatives would face significant opposition from the boating community.

**2.2 Structural Impacts on the Existing Bridge**

The Anderson Memorial Bridge is a 3-span reinforced concrete arch structure with a clear span at spring line of 65'-4" at the end spans, and 75'-6" at the center span. The abutments at the end span of the arches are comprised of concrete and rubble-concrete construction.

The following structural types have been considered for the various underpass alternatives:

**Underpass Tunnel Structure**

Alternatives (1A, 1B, 3A, and 3B) call for a concrete box tunnel that can be either precast or cast-in-place (see Figures 11-14, and 16-17). Construction of the tunnel would have a structural impact on the existing structure, and would impact the project's design and construction schedules, in terms of structural modifications to the bridge approach walls and design and implementation of stage construction.

**Boardwalk Structure**

Alternatives 2 and 4 (see Figure 15), call for a treated timber boardwalk under the exterior arches. The boardwalk would be supported on mini-piles due to

***Bike and Pedestrian Underpass Feasibility Study***

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constrained headroom, and would be structurally independent from the existing bridge. The boardwalk alternative would impact the bridge design and construction schedules in terms of navigation traffic management to keep two channels open at all times during construction, in coordination with the repair of the underside of the concrete arches.

**Southeast Wingwall – Boston Approach****Southwest Wingwall – Boston Approach****Northwest Wingwall – Cambridge Approach****Northeast Wingwall – Cambridge Approach****Elevation View of the Approach Walls****Arch and Abutment Impacts**

Preliminary analysis indicates that the existing timber piles that support the bridge abutments do not have sufficient capacity to resist the thrust on the arches without the benefit of the passive soil behind the abutment. Therefore, a bracing support system would be needed to excavate and install the underpass tunnel behind the abutments without a structural adverse impact to the bridge. We would recommend that the abutments be monitored during construction. The reason for concern stems from the fact that the abutments have benefitted from passive and at-rest soil pressure against the abutments for almost 100-years and this secondary lateral support system may be sharing the lateral load with the timber piles. Removal of the soil could result in a load transfer back to the pile

***Bike and Pedestrian Underpass Feasibility Study***

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group and lead to some longitudinal movements, which could potentially lead to cracking within the arch. This could be mitigated via strutting across the excavation and including excavation/staging sequence restrictions in the construction contract.

The additional bracing, monitoring and excavation/sequencing controls would have cost and schedule impacts to the project.

**Approach Wall Impacts**

The existing approach walls are deteriorated to the point that they need to be completely replaced. The new walls could be designed to include the underpass tunnel and there would be cost and schedule impacts.

**2.3 Civil Alignment and Profile of the Underpasses**

The alignments and profiles for each alternative have been provided herein (see Figures 1 thru 10). The alignments were developed to suit existing conditions and constraints, such as the rerouting of the pipelines. The profiles were also developed to avoid adverse impacts where possible, provide minimum cover over the tunnel and to avoid having low points within the underpass tunnels.

**2.4 Right-of-Way**

All properties that would be impacted by the proposed underpasses along both sides of the Charles River are owned and managed by the Massachusetts Department of Conservation and Recreation (DCR). This includes the land where the Weld Boathouse is located, which is under a lease agreement with the Commonwealth of Massachusetts.

**2.5 Utility Impacts**

There are a number of utilities that run along the Anderson Memorial Bridge that would need to be relocated or temporarily supported to facilitate construction of the underpasses. The impacted existing utilities include:

**MWRA Water Mains**

There are two water mains on the bridge, each is a 30" line under the east and west sidewalks. The two lines run over the top of the arches and reconnect into a single 48" line approximately 50 to 60 feet behind the back face of both abutments. The water mains are owned by the Massachusetts Water Resources Authority (MWRA) and are an integral part of the Spot Pond West pipeline (identified as Section 10). The Spot Pond West pipeline is one of two pipelines that convey water supply from south to north as part of the MWRA's Low Service distribution system. The pipelines are comprised of cast iron pipe on the bridge



***Bike and Pedestrian Underpass Feasibility Study***

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that transitions to concrete encased pipe within the approaches. Although these pipelines are critical elements within the MWRA's water distribution system, we feel after discussions with MWRA that they could be temporarily taken out of service and locally reconfigured if necessary to support the bridge rehabilitation and/or the underpass construction.

**Conduits**

There are two concrete encased duct banks on the bridge: a telephone duct bank under the west sidewalk and an MBTA electric duct bank under the east sidewalk. These duct banks could be reconfigured, if necessary to accommodate an underpass.

**Miscellaneous Utilities**

There are electrical conduits that feed the street lighting, and surface mounted 1 inch steel conduits on the fascia for the navigational lights. These utilities in the area of the bridge approach walls could be supported in place or relocated to accommodate the underpass construction.

**Major Utility Impact and Mitigation**

The most critical utility with respect to the construction of the underpasses are the MWRA water mains. We currently anticipate in the bridge rehabilitation project (without underpasses), that these lines would be replaced and that isolation valves would be installed at each approach.

However, the existing pipeline alignments and profiles at the approaches pose a significant hurdle to the construction of the pedestrian underpasses. There are two options with respect to mitigating the impact of the water mains: 1- reroute the pipelines (Alternatives 1A and 2A) or 2- constructing the underpass below the water lines which places the top of the floor slab below the normal water level in the river (Alternatives 1B and 2B). Installing the underpass beneath the water lines would require positive means to control the water and could have long-term maintenance issues.

With respect to rerouting the pipelines, we assessed the following two options:

1. Reconfigure the pipelines such that the two lines are connected just behind the abutment into a new single 48-inch line that would run parallel between the underpass and the back face of the abutment and under the approach wall. This would require approximately 10 feet of clearance between the abutment and the underpass. From here, the line would run parallel to the pathway for a length sufficient to allow the pipe to run under the underpass and reconnect to the original alignment.

***Bike and Pedestrian Underpass Feasibility Study***

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2. The interference could also be eliminated, if the entire waterlines running across the bridge were replaced with a new crossing under the river via directional drilling or other soft ground tunneling techniques. This assumes that a suitable site could be found, which is beyond the scope of this report. This option would be very costly, have major schedule and permitting impacts and would need to be done as a separate MWRA project. Based on these issues, we have assumed that this option is not feasible with respect to constructing the underpass at this time.

## **2.6 Cultural Resources**

The following is a preliminary assessment of potential historic issues related to adding underpasses to the approaches of the Bridge:

### **Underpass Alternatives**

Boston (Allston) Approach – The addition of an underpass through the Boston approach walls would have an adverse effect on the historical integrity of the Anderson Memorial Bridge. This would require an alternative analysis under the Section 106 or the Chapter 254 review process and would substantially affect the project schedule.



Cambridge Approach – The northwest approach wall on the Cambridge side has a stair structure connecting the bridge (North Harvard Street) to the park area along the Charles. The stair structure is a character-defining historic feature of the bridge and is located within the vicinity of where the underpass would need to be installed. Adding the underpass would require the elimination or major reconfiguration of the stairway, which contains significant architectural features, such as the balustrades and railing that are defining features of the bridge. Eliminating the stairway or a major reconfiguration would result in an adverse effect. Getting this reviewed and approved would have a significant impact on the project schedule.

The other issue related to the underpass on the Cambridge approach is the presence of the Weld Boathouse at the northeast corner of the bridge. Built in 1907, the boathouse is within and is a contributing component to the Charles River Basin National Register-listed Historic District. The path to connect the underpass with the existing sidewalk would require retaining walls and/or regrading of the grounds surrounding the boathouse (see photo). Even though

***Bike and Pedestrian Underpass Feasibility Study***

the actual boathouse structure would not be directly impacted, the setting of the building would be impacted.

In summary, an underpass on either side of the bridge would have an adverse effect on the bridge and the Historic District under Section 106 or Chapter 254 review. The project ultimately requires the approval of the State Historic Preservation Officer (SHPO).



Area between Weld Boathouse & Northeast approach wall

**Boardwalk Alternatives (both approaches)**

The addition of a boardwalk under the bridge exterior arches and the associated approaches in front of the bridge wingwalls could have an adverse effect on the Historic District. The project would need to be approved by the State Historic Preservation Officer (SHPO), which would potentially impact the project schedule.

**Archaeological**

Alternatives 1A and 1B (underpass on the north side of the bridge) require additional excavation where the pathways tie into the underpass. This will require additional research to determine if there is potential to impact a site of prehistoric activity on the north side of the Anderson Bridge. An inventoried archaeological site was identified within the DCR's Master Plan for the Charles River Basin.

**2.7 Environmental Permitting**

As a sub consultant to FST, CDW Consultants, Inc. prepared a "*Preliminary Summary Report of Anticipated Permits and Approvals*" dated November 2009. The report was prepared in collaboration with, and under the review of MassDOT Environmental Section. This report was specific to the proposed rehabilitation of the Anderson Memorial Bridge and did not include the underpass options discussed herein. The report assumed that the permanent modifications and repairs would stay within the footprint of the existing bridge and that all work would take place within the 100-foot buffer zone and require the use of barges in the Charles River. The project's 25% Design submittal included the removal of more than five public shade trees of 14 or more inches in diameter at breast height. Based on these assumptions and the 25% Design, CDW in collaboration with MassDOT Environmental Section determined that the following environmental permits would be required for the proposed bridge rehabilitation project:

***Bike and Pedestrian Underpass Feasibility Study***

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- Programmatic Categorical Exclusion (CE) under the National Environmental Policy Act (NEPA) is not anticipated at this time. This will become required, along with 4(f) evaluation, should Federal funding be used in the future of the project.
- Letter of Construction issued to U.S. Coast Guard (USCG) is required to coordinate construction services. A US Coast Guard permit is required if there will be a change to the dimensions of the hydrological opening, which we do not anticipate at this time.
- A US Army Corps of Engineers permit may be required for the proposed rehabilitation project depending on the extent of work to the riprap and abutments. However, based on the 25% Design, it is anticipated that the proposed work may occur under the Maintenance Exemption of the Massachusetts Programmatic Agreement.
- Historical review and approval by the State Historic Preservation Officer (SHPO). Since Federal funding or permits (ACOE or USCG) are not anticipated, then Section 106 Historical review may not be required, in which case a Chapter 254 Historical review will occur. FST/CDW and MassDOT Cultural Resources Unit feel that an adverse effect determination may be avoided if the project is constructed as designed at 25% Design.
- The filing of Notices of Intent (NOIs) with the Boston and Cambridge Conservation Commissions in accordance with the Massachusetts Wetlands Protection Act (MGL. c. 131 s 40) and its implementing Regulations (310 CMR 10.00) will be required.
- Environmental Notification Form (ENF) under the Massachusetts Environmental Policy Act (MEPA) Regulations (301 CMR 11.00). An ENF filing is required due to the removal of public shade trees (more than 5 with diameters of 14 inches and more).

The following is a summary by FST in collaboration with CDW and MassDOT on the **additional** environmental clearances that may be required if the project scope was expanded to include a bicycle and pedestrian underpass tunnel or boardwalk structure.

**Tunnel Alternatives**

The proposed tunnel alternatives (Alternatives 1A, 1B, 3A and 3B) call for construction within the 100-foot buffer zone to Bank, 25-foot Riverfront Area, and Bordering Land Subject to Flooding BLSF, known as the 100-year floodplain) associated with the Charles River.



***Bike and Pedestrian Underpass Feasibility Study***

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MA DEP Chapter 91 License

The Anderson Memorial Bridge is a licensed structure under the MA Department of Environmental Protection (DEP) Chapter 91 Program. The construction of an underpass may require an amendment to the existing Chapter 91 license to authorize a structural alteration or the filing of a new Chapter 91 license if the structural alteration is deemed substantial.

Additional research will be required to determine if the proposed activities are located on filled tidelands. A pre-application consultation meeting with DEP would be recommended to discuss the proposed change in project scope.

Section 106 / Chapter 254 Historical review and approval by the State Historic Preservation Officer (SHPO).

An adverse effect determination will not be avoided with the proposed underpasses, and will require a review and approval by the State Historic Preservation Officer (SHPO).

The project will be reviewed under Chapter 254 or Section 106, depending on whether Federal permits or funding are required/utilized. While a no adverse effect determination is anticipated for the project as designed at 25%, the addition of the tunnels will trigger an adverse effect determination for the bridge or the Historic District. Coordination and additional alternatives analysis would be needed for the historical review and would cause significant schedule delays.

**Boardwalk Alternatives**

The proposed boardwalks - Alternatives 2 and 4 (Figures 5 and 10), call for work within Land Under Waterbodies (LUW), Bank, 100-foot buffer zone to Bank, 25-foot Riverfront Area, and Bordering Land Subject to Flooding (BLSF) (known as the 100-year floodplain) associated with the Charles River and result in permanent impacts to these resource areas. It is anticipated that boardwalk construction would take place from a barge and would be limited to the construction of the support bents and mini-pile foundations. Boardwalk construction within the Charles River would require the following additional environmental clearances:

U.S. Coast Guard (USCG) Permit

Boardwalk construction under the exterior concrete arch would reduce the existing hydraulic opening at the Anderson Memorial Bridge. Therefore, the project would require filing an application for a USCG bridge permit pursuant to Section 9 of the Rivers and Harbors Act and the General Bridges Act.

U.S. Army Corps of Engineers (ACOE) Section 10 General Permit

***Bike and Pedestrian Underpass Feasibility Study***

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The boardwalk alternatives would require an ACOE Category 2 General Permit under section 10, as a boardwalk would be a structure in a navigable waterway. Geotechnical borings within the Charles River would be required for the design of the boardwalk foundations. Consequently, this would also require the preparation of Category 1 Form in accordance with the U.S. Army Corps of Engineers (ACOE) Section 10 Programmatic General Permit (PGP).

Section 106/Chapter 254 Historical review and approval by the State Historic Preservation Officer (SHPO).

Since USCG and ACOE permits would be required, then Section 106 Historical review would be required, instead of the Chapter 254 review that is anticipated for the bridge rehabilitation without underpasses/boardwalks. An adverse effect determination would not be avoided with the boardwalk alternatives, and would require a review and approval by the State Historic Preservation Officer (SHPO).

Water Dependent Chapter 91 License

The boardwalk would be located within a non-tidal, navigable waterway and would not be a previously licensed structure. Therefore, pursuant to the Massachusetts Chapter 91 Waterways Act, an application would need to be filed with MA Department of Environmental Protection (DEP) for a Water Dependent Chapter 91 License.

401 Water Quality Certification (WQC)

Boardwalk construction may also require the filing of 401 WQC applications to MA DEP in accordance with the Massachusetts Surface Water Quality Standards (314 CMR 4.00). Based on the nature of the project, it is assumed that the extent of project impacts would only require filing for minor project certifications.

Environmental Notification Form (ENF) under the Massachusetts Environmental Policy Act (MEPA)

The project would exceed an additional threshold for filling an Environmental Notification Form (ENF) in accordance with the Massachusetts Environmental Policy Act (MEPA) due to the construction of a boardwalk 2,000 or more square feet in base area in flowed tidelands or other waterways [301 CMR 11.03(3)(b)(6)].

Supplemental Notice of Intent (NOI) filing with the Boston and Cambridge Conservation Commissions

Geotechnical borings within the Charles River for the design of the boardwalk foundations, would require a supplemental Notice of Intent (NOI) filing with the Boston and Cambridge Conservation Commissions in accordance with the Massachusetts Wetlands Protection Act (MGL. c. 131 s 40) and its implementing Regulations (310 CMR 10.00).

***Bike and Pedestrian Underpass Feasibility Study***

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**2.8 Public Safety and Increased Security Patrols**

Both, the underpass tunnel and boardwalk alternatives raise crime and safety concerns to the public. Despite providing good lighting, the tunnel and/or boardwalk may present a somewhat long and dark location for crime potential. This highlights the need for added police/security patrols and/or surveillance of the access and paths by the responsible agency or city.

**2.9 Improvements to Existing At-Grade Crossings**

The proposed rehabilitation of the Anderson Memorial Bridge will include pedestrian improvements at the signalized roadway crossings of JFK Street in Cambridge and North Harvard Street in Boston. Improvements will consist of new ADA compliant cement concrete wheelchair ramps with detectable warning panels, new painted crosswalks, and necessary modifications to the existing signal equipment consistent with current accessibility requirements for pedestrian crossings. These improvements have been presented at public meetings, allow the project to approximate completion with the current schedule and estimate, and most significantly offer a context-sensitive option that avoids an adverse effect to the historical integrity of the bridge and Historic District.

**3.0 Schedule Impacts****3.1 Design and Permitting Impacts****Underpass Tunnel Alternatives (Cambridge/Boston)**

The design schedule, including the permitting process, would be impacted if the underpasses are added to the rehabilitation project. In addition, including the underpass tunnels as part of the rehabilitation would add considerable schedule risk to the project due to the unknowns associated with the historic review/approval process and the potential for legal challenges. Another risk factor would be the need to coordinate, design and gain approval for the rerouting of the MWRA's water mains.

**Boardwalk Alternatives (Cambridge/Boston)**

The boardwalk alternatives would have considerable permitting challenges that would result in significant schedule impacts. They would require USCG and ACOE permitting, as the boardwalk would be a structure in a navigable waterway, would change the hydraulic opening, and restrict the channel navigation by boaters and use by rowers.

Since the boardwalk construction can be made independent of the bridge, these alternatives could be implemented as a separate contract.

***Bike and Pedestrian Underpass Feasibility Study***

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The Boston and Cambridge Boardwalk alternatives would have similar conditions and design and permitting parameters. Anticipated delays associated with permitting, historic reviews, and coordination with the boating and rowing community would be significant.

### **3.2 Construction Impacts**

The estimated construction duration for the Rehabilitation of the Anderson Memorial Bridge, without underpasses is 30 months.

Although some of the underpass work could be done concurrently with the baseline construction tasks, we estimate that the underpasses (tunnel options) would add 6 months to the construction schedule. The major factors would include the following:

- Rerouting of the water mains.
- Excavation, bracing, monitoring and installation of the underpass tunnels.
- Pile driving would be required for the underpass tunnel on the Cambridge approach.
- Path construction (the path footprint would likely be used to stage the approach wall reconstruction so it cannot be done concurrently).

Although the boardwalk construction is not dependent of the Anderson Bridge rehabilitation work, it would require coordination with the project. We estimate that the underpasses (tunnel options) would also add 6 months to the construction schedule. The major factors would include the following:

- Navigation traffic management to keep two channels open at all times during construction, in coordination with the repair of the underside of the concrete arches.
- Mini-Pile and Pile bent construction, in addition to the construction of the boardwalk superstructure.
- Path construction (the path footprint would likely be used to stage the approach wall reconstruction so it could not be done concurrently).

## **4.0 Summary of Findings**

### **4.1 Feasibility**

In summary, the underpass tunnels or the boardwalks are structurally feasible, but have adverse impacts to the character defining features of the bridge and the surrounding area, with associated risks to the project schedule.



***Bike and Pedestrian Underpass Feasibility Study***

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Alternatives 1A for the Cambridge approach and Alternative 3A for the Boston approach require the relocation of the water mains, to keep the underpass' profile above the normal water level of the Charles River. In addition Alternative 1A impacts the northwest stairs at the Cambridge approach, which would significantly alter the bridge's overall appearance. These alternatives would face a lengthy and uncertain permitting process.

Providing underpasses that are below the normal water level in the river (Alternatives 1B and 3B) would create long-term maintenance problems and would significantly alter the overall appearance of the approaches, where the approach walls would be partially blocked by retaining walls, boat sections and railings. These alternatives would also face a lengthy and uncertain permitting process.

The timber boardwalk under the exterior arches (Alternatives 2 and 4) would change the hydraulic opening, and significantly reduce the navigable channel width which would restrict boat navigation and channel use by the rowing community. Boardwalks would face a lengthy and uncertain permitting process and significant opposition from the boating and rowing community.

**4.2 Impact to the project schedule**

The design schedule, including the permitting process would be impacted if the underpasses are added to the rehabilitation project.

**4.3 Estimated Project Cost Increases**

A summary of the estimated construction and maintenance costs for each alternative is presented below. The permitting and engineering and administration costs are not included.

The maintenance costs are estimated based on current 2010 values. They include snow removal, lighting, landscaping, drainage, sweeping and cleaning, and miscellaneous items such as periodic inspections and repairs. In addition, the maintenance cost for the tunnel alternatives includes the maintenance of a sump and pumping system.

The maintenance costs do not include the cost of security patrolling and surveillance. The estimated design schedule impact in the table below does not account for permitting which would be significantly longer than the design time.

***Bike and Pedestrian Underpass Feasibility Study***

Alternative		Estimated Project Cost Increase to Add Underpasses	Estimated Annual Maintenance Costs (2010)
Alternative 1A	Underpass with Relocated Water Mains - Cambridge	\$2,400,000	\$24,000
Alternative 1B	Underpass Located Below Water Mains - Cambridge	\$2,335,000	\$26,000
Alternative 2	Boardwalk Under Exterior Arch – Cambridge	\$1,170,000	\$25,000
Alternative 3A	Underpass with Relocated Water Mains - Boston	\$2,850,000	\$24,000
Alternative 3B	Underpass Located Below Water Mains - Boston	\$2,945,000	\$26,000
Alternative 4	Boardwalk Under Exterior Arch – Boston	\$1,760,000	\$25,000

**4.4 Not to Preclude Option**

It has been suggested at public meetings that if MassDOT does not install the underpasses as part of the bridge rehabilitation project they should consider pursuing a design that facilitates the construction of tunnel underpasses in the future. Structural modifications that could be made to the bridge approach walls based on the assumption that underpasses would be constructed in the future include, but are not limited to the following:

- Designing the pile arrangement for the approach walls to account for a future tunnel/opening.
- Providing supplemental reinforcing in the wall to suit a future opening.
- Dedicate an area below the wall for rerouting the waterline without impacting the wall.

If these options are pursued, the bridge rehabilitation project would still be subject to potential schedule delays associated with underpass permitting and historical review processes.

## **APPENDIX A**

### **Fundamentals of Rowing the Charles**

## The Fundamentals of Rowing on the Charles

1. 12 boathouses
2. 900 shells total
3. 500 shells with coxswains (i.e., someone is looking forward)
4. 400 shells without coxswains (i.e. no one is looking forward)
5. 2,000 – 2,500 people rowing on the river over the course of a sunny day in the spring, summer and fall
6. The Charles River at Anderson Bridge is equivalent to the interchange of the Mass Pike and 128 at 8:00 am
7. There are multiple collisions; many have been hurt
8. Collisions with the work barge have been many over the last year
9. Attention to safety for the rowing public has been variable



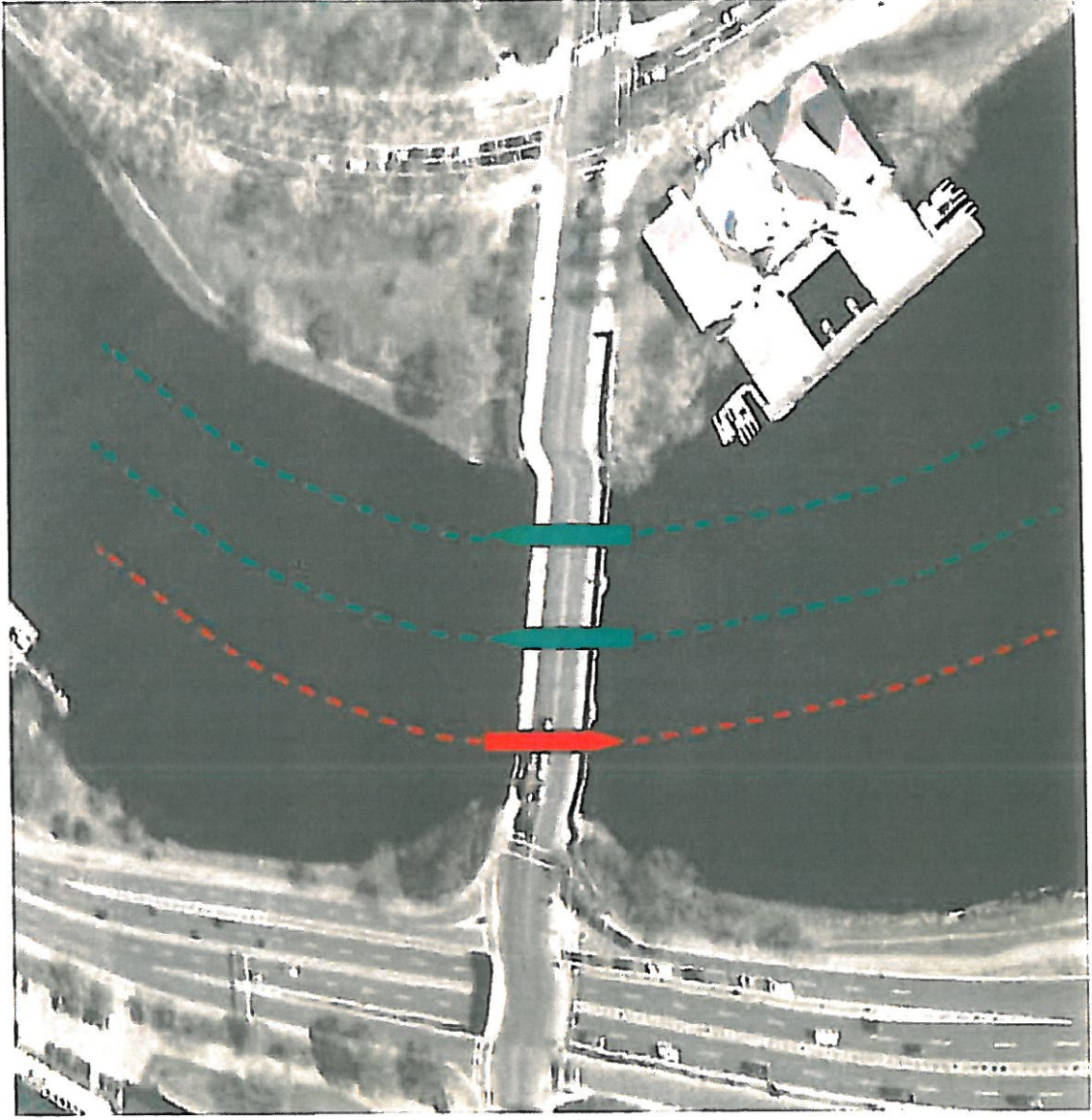
The dangers to the rowing public of work on the Anderson Bridge must be recognized and managed diligently by the work crews and the relevant authorities.

The solutions are simple and easy to implement.

## Rowing Traffic Patterns through Anderson Bridge

- Upstream traffic uses the Cambridge and center arches
- Downstream traffic uses the Boston arch
- Overtaking boats have right of way

Upstream towards Watertown



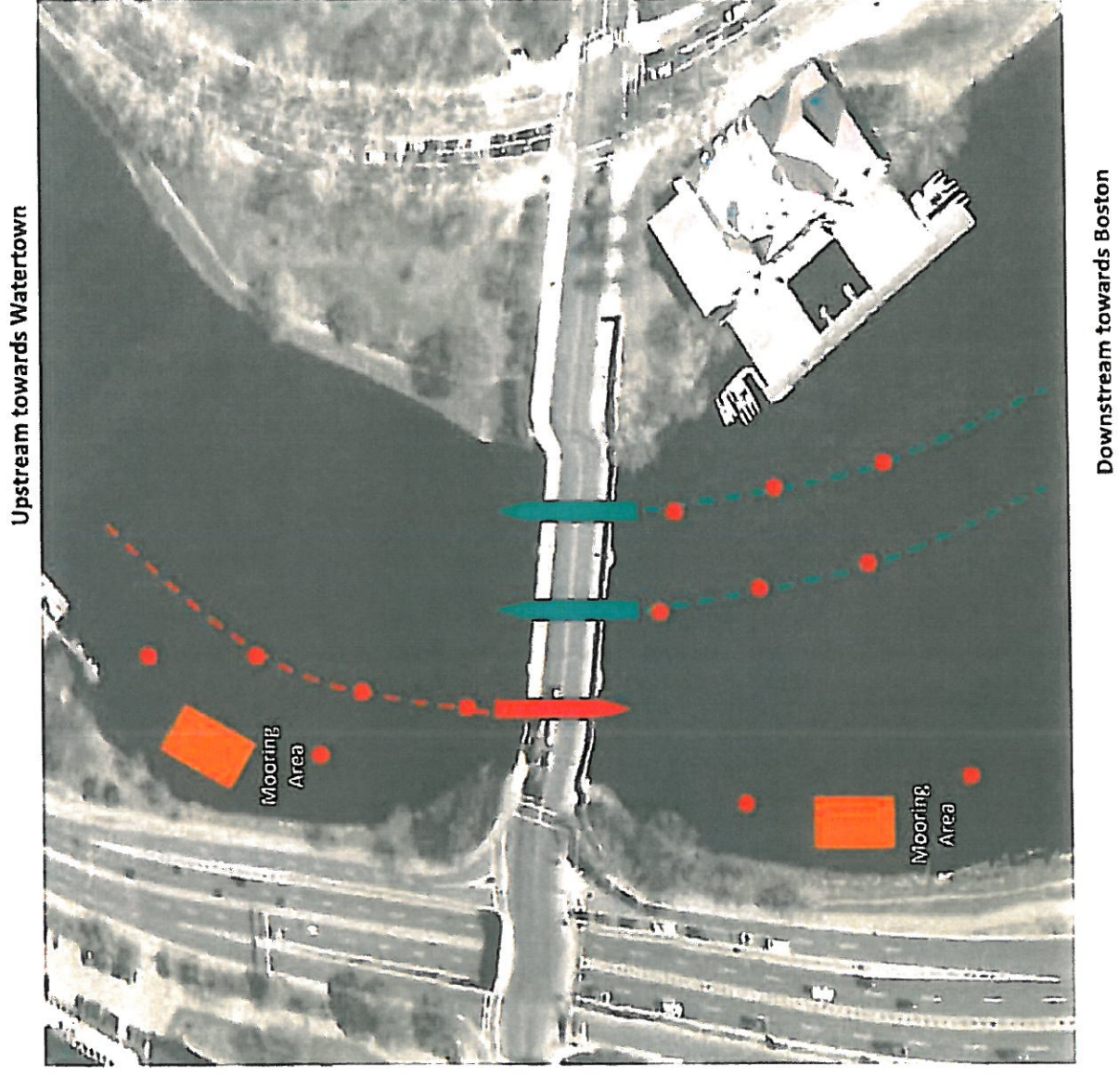
Downstream towards Boston



## Proposed Safety Rules while Repairing the Anderson Bridge

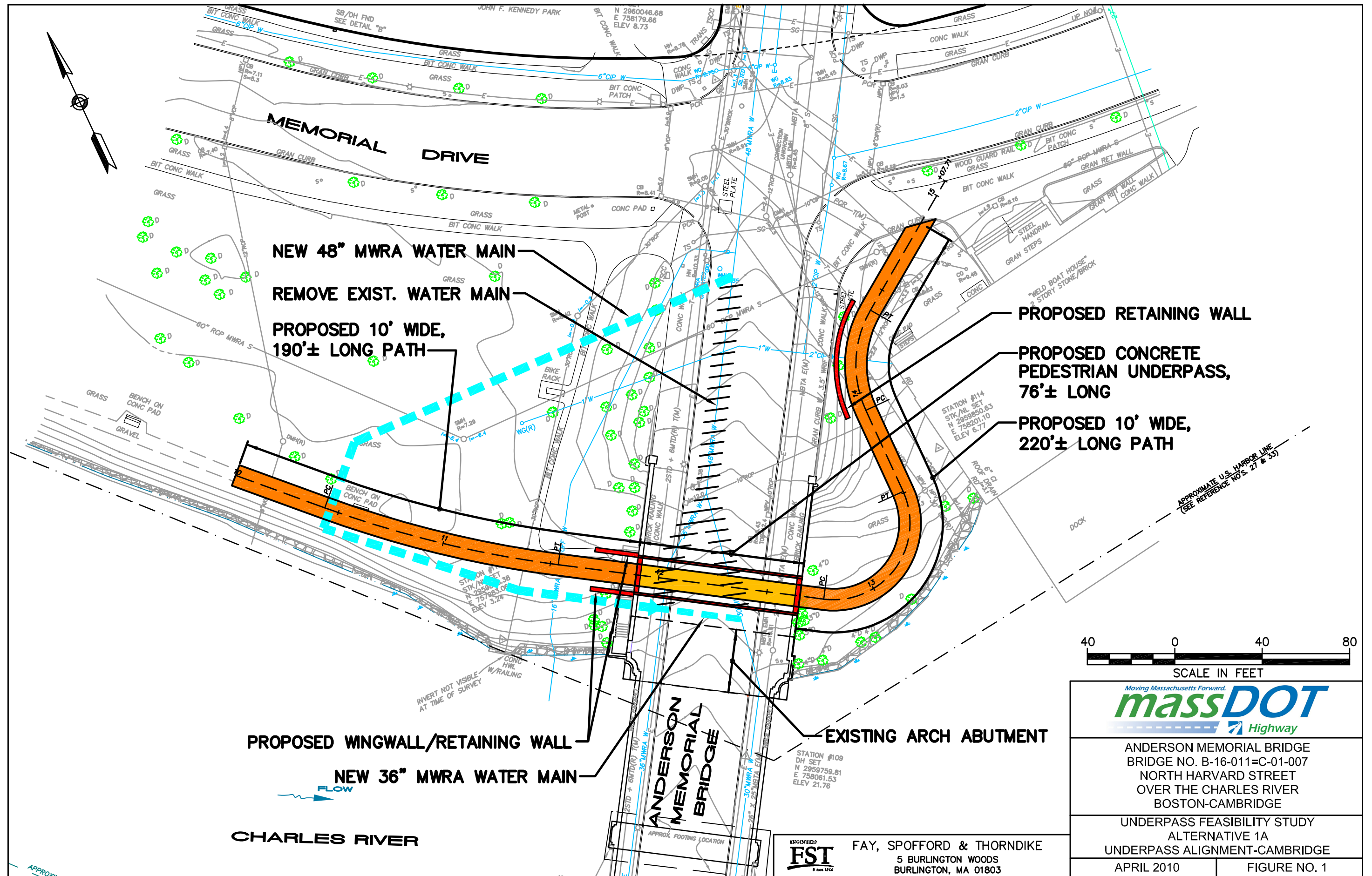
- Whenever a barge obstructs an arch or any work is likely to create danger in passing through an arch, place three warning buoys 25, 50 and 75 yards downstream of the center and Cambridge arches or 25, 50 and 75 yards upstream of the Boston arch.
- When the obstruction is removed or the work no longer creates any danger, remove the buoys.
- When a barge is not in use, moor it where it doesn't obstruct rowing traffic and place a buoy 25 yards up and downstream of it.

- ## Proposed Safety Rules while Repairing the Anderson Bridge
- Whenever a barge obstructs an arch or any work is likely to create danger in passing through an arch, place three warning buoys 25, 50 and 75 yards downstream of the center and Cambridge arches or 25, 50 and 75 yards upstream of the Boston arch.
  - When the obstruction is removed or the work no longer creates any danger, remove the buoys.
  - When a barge is not in use, moor it where it doesn't obstruct rowing traffic and place a buoy 25 yards up and downstream of it.

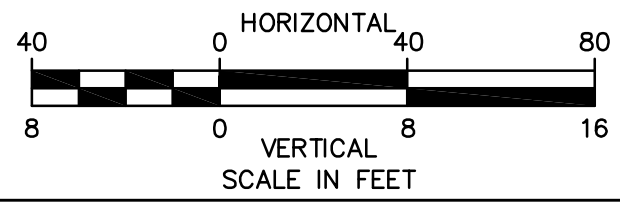
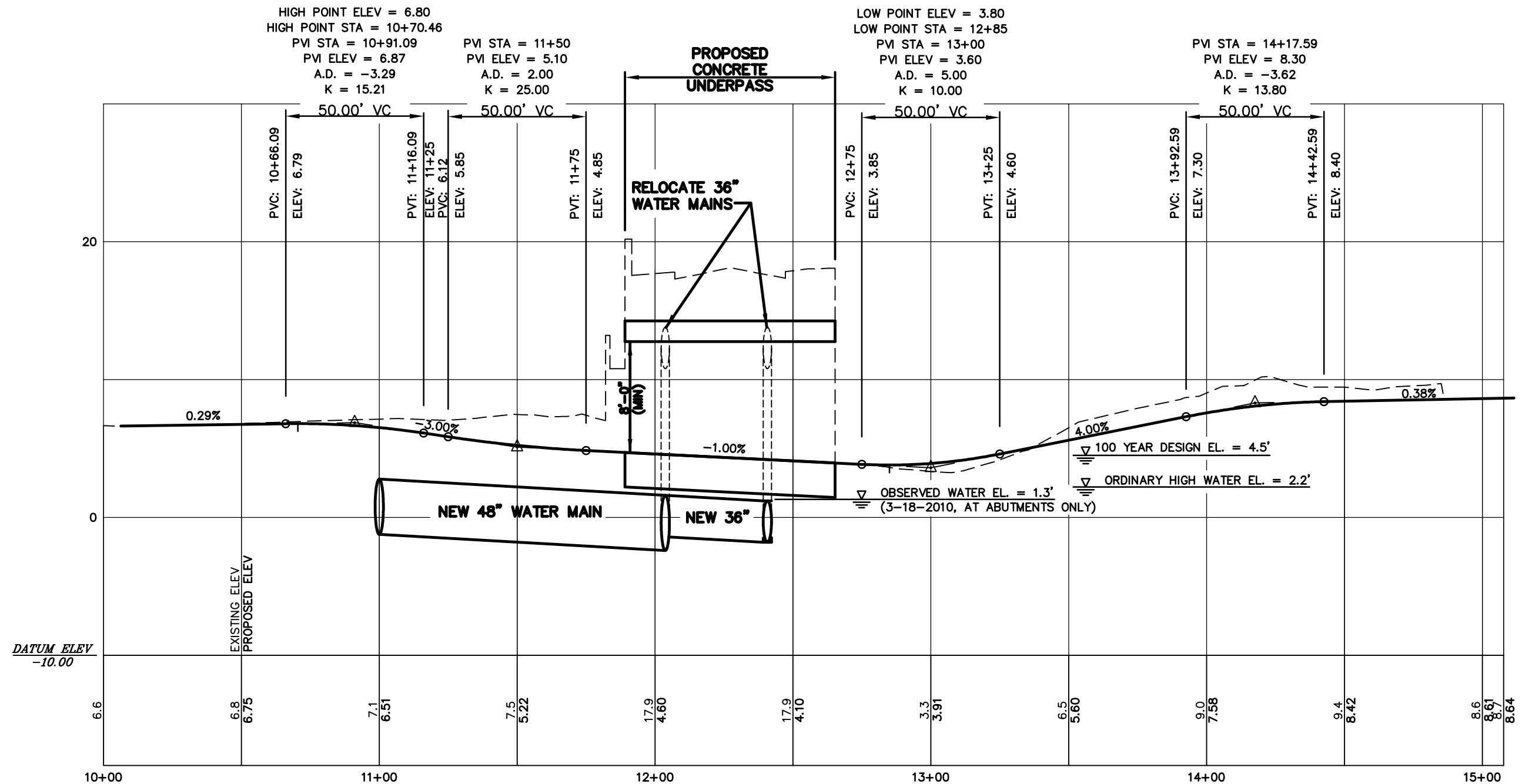


## **APPENDIX B**

**Figures 1 to 19**







FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

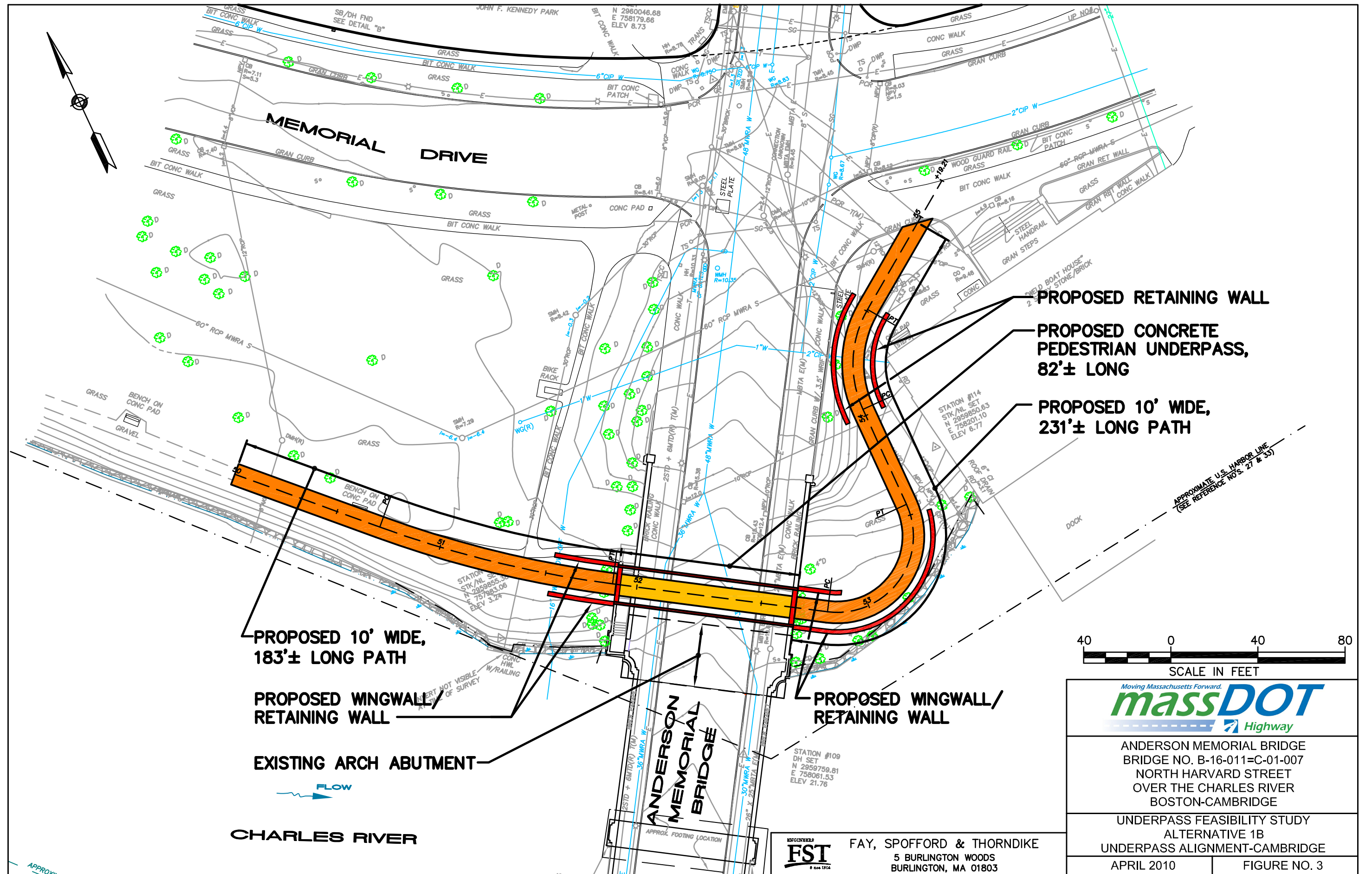


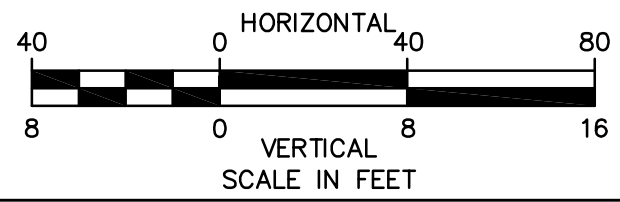
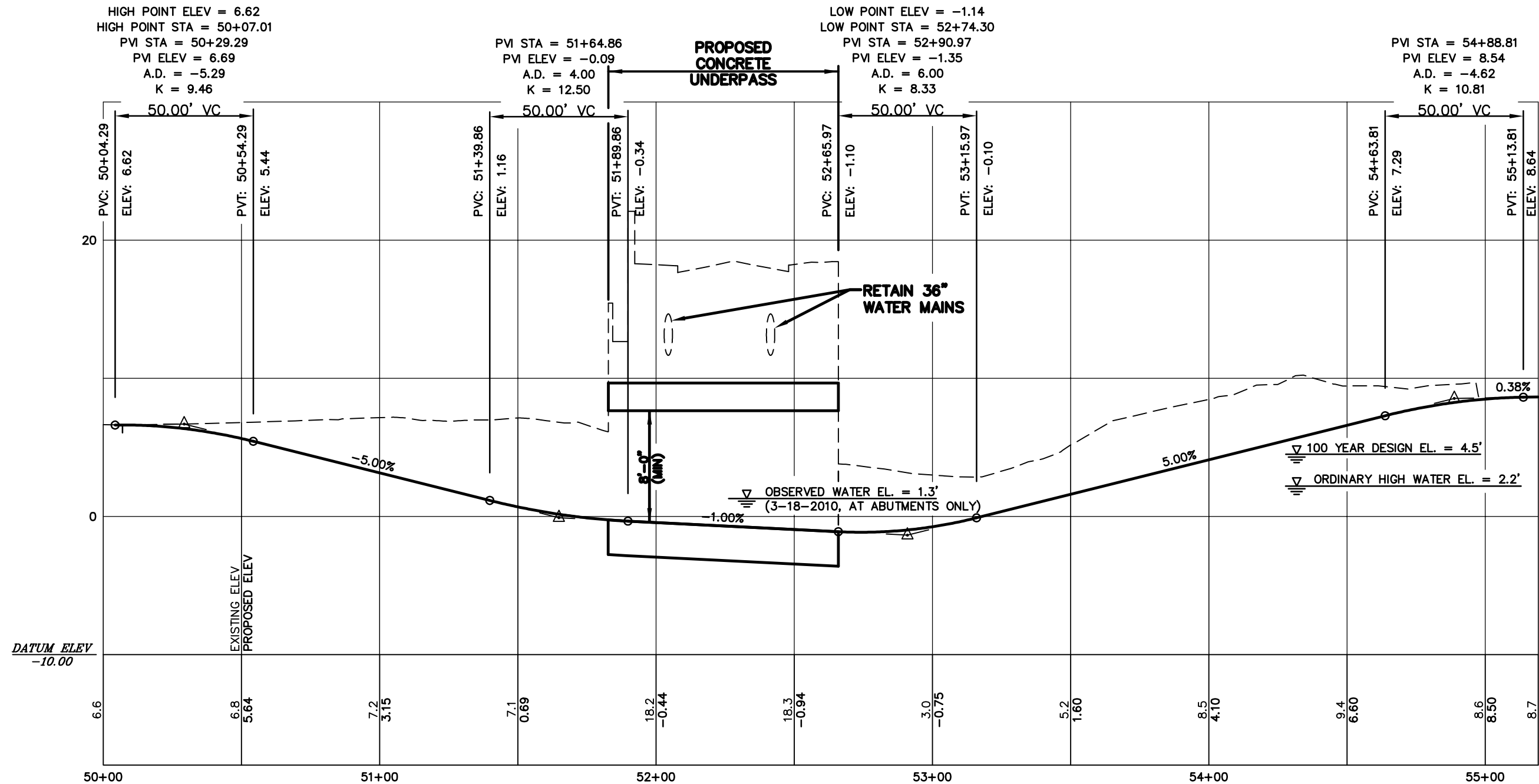
ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 1A  
UNDERPASS PROFILE-CAMBRIDGE

APRIL 2010

FIGURE NO. 2





FAY, SPOFFORD & THORNDIKE  
 5 BURLINGTON WOODS  
 BURLINGTON, MA 01803



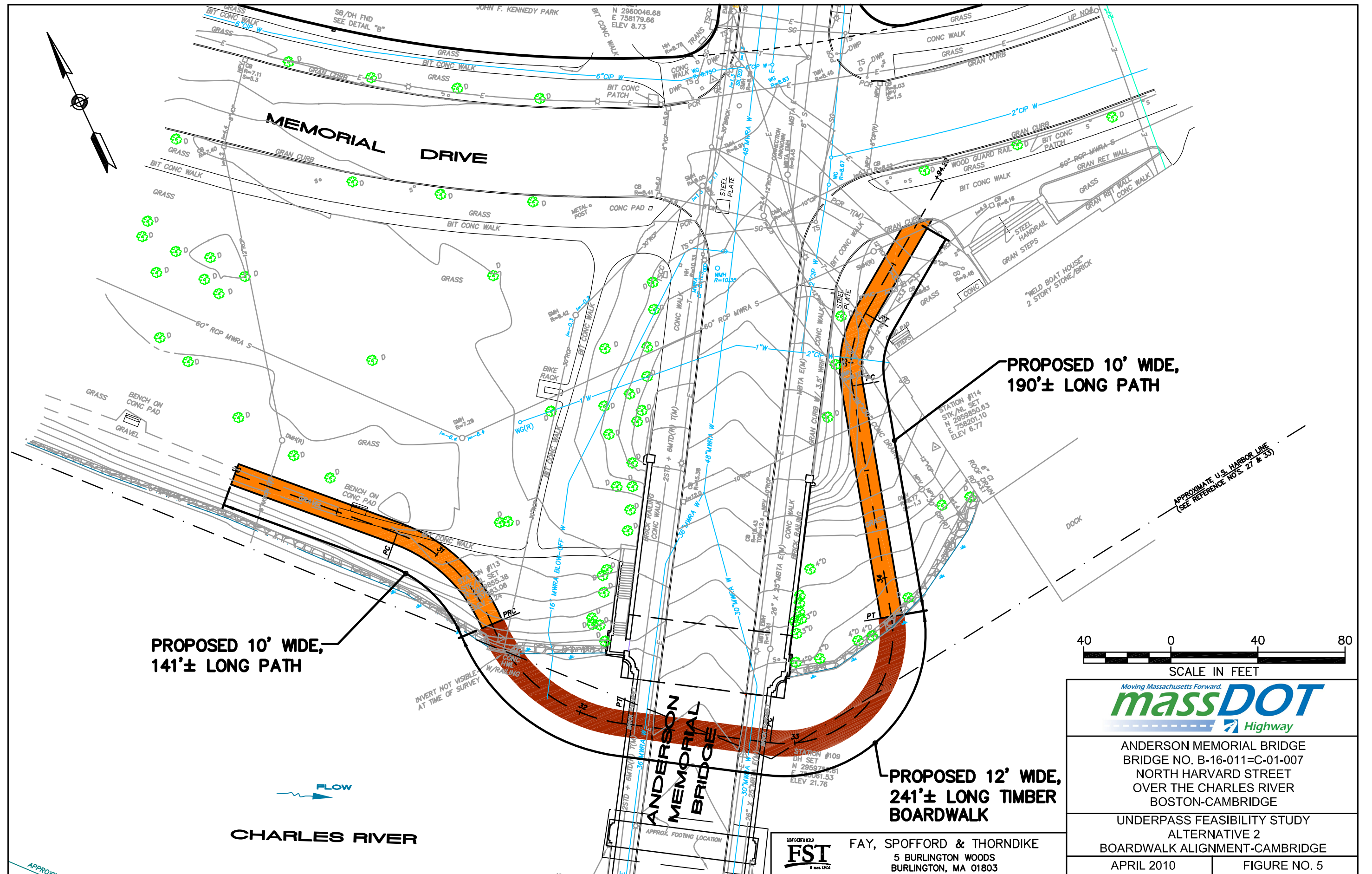
ANDERSON MEMORIAL BRIDGE  
 BRIDGE NO. B-16-011=C-01-007  
 NORTH HARVARD STREET  
 OVER THE CHARLES RIVER  
 BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
 ALTERNATIVE 1B  
 UNDERPASS PROFILE-CAMBRIDGE

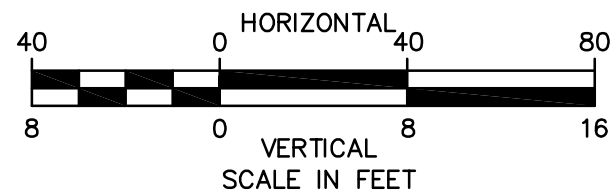
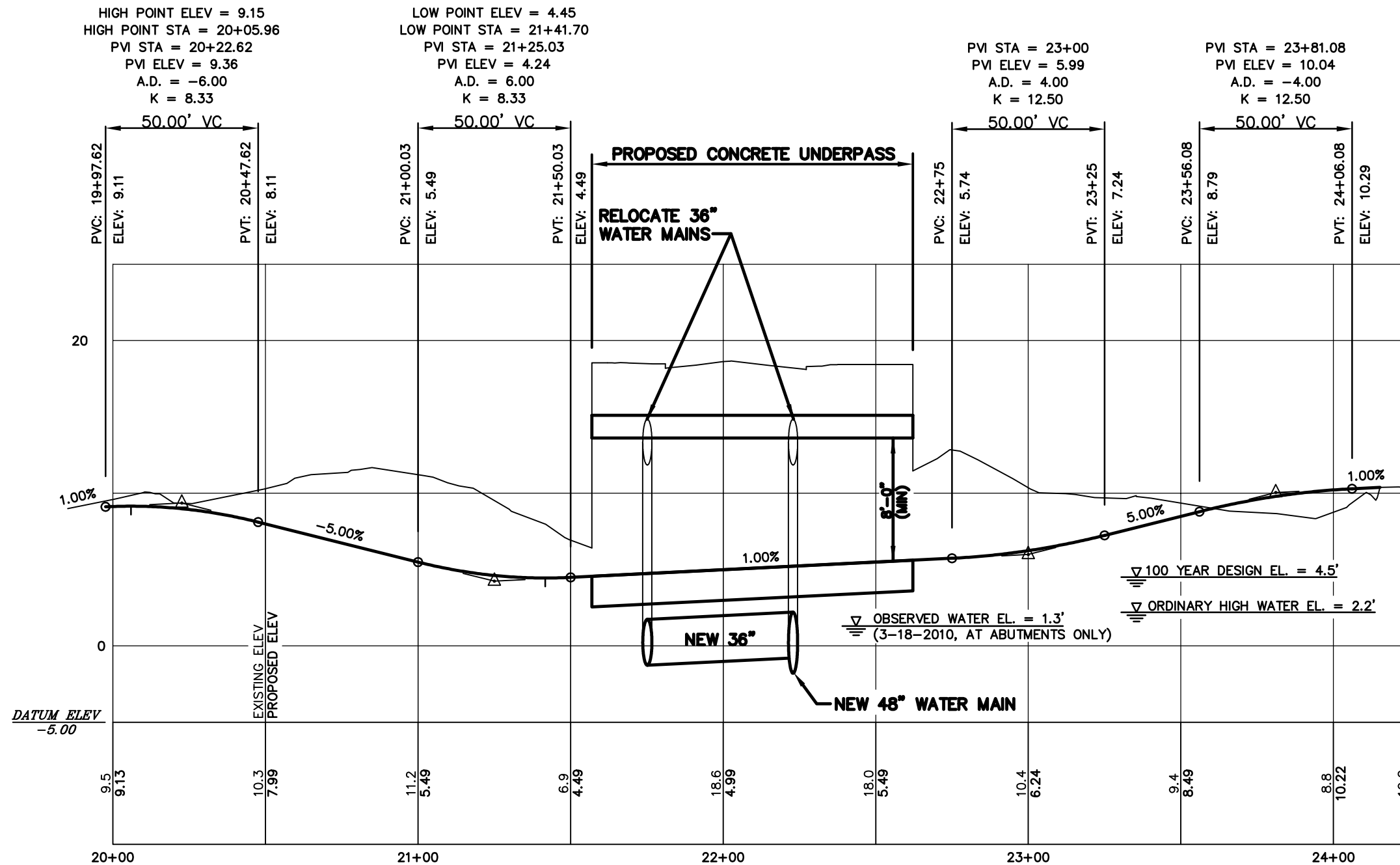
APRIL 2010

FIGURE NO. 4









FAY, SPOFFORD & THORNDIKE  
 5 BURLINGTON WOODS  
 BURLINGTON, MA 01803



ANDERSON MEMORIAL BRIDGE  
 BRIDGE NO. B-16-011=C-01-007  
 NORTH HARVARD STREET  
 OVER THE CHARLES RIVER  
 BOSTON-CAMBRIDGE

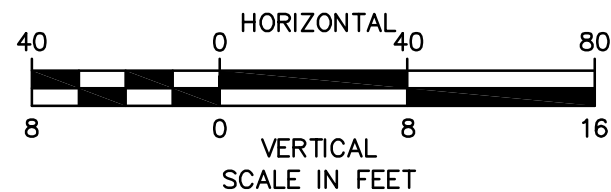
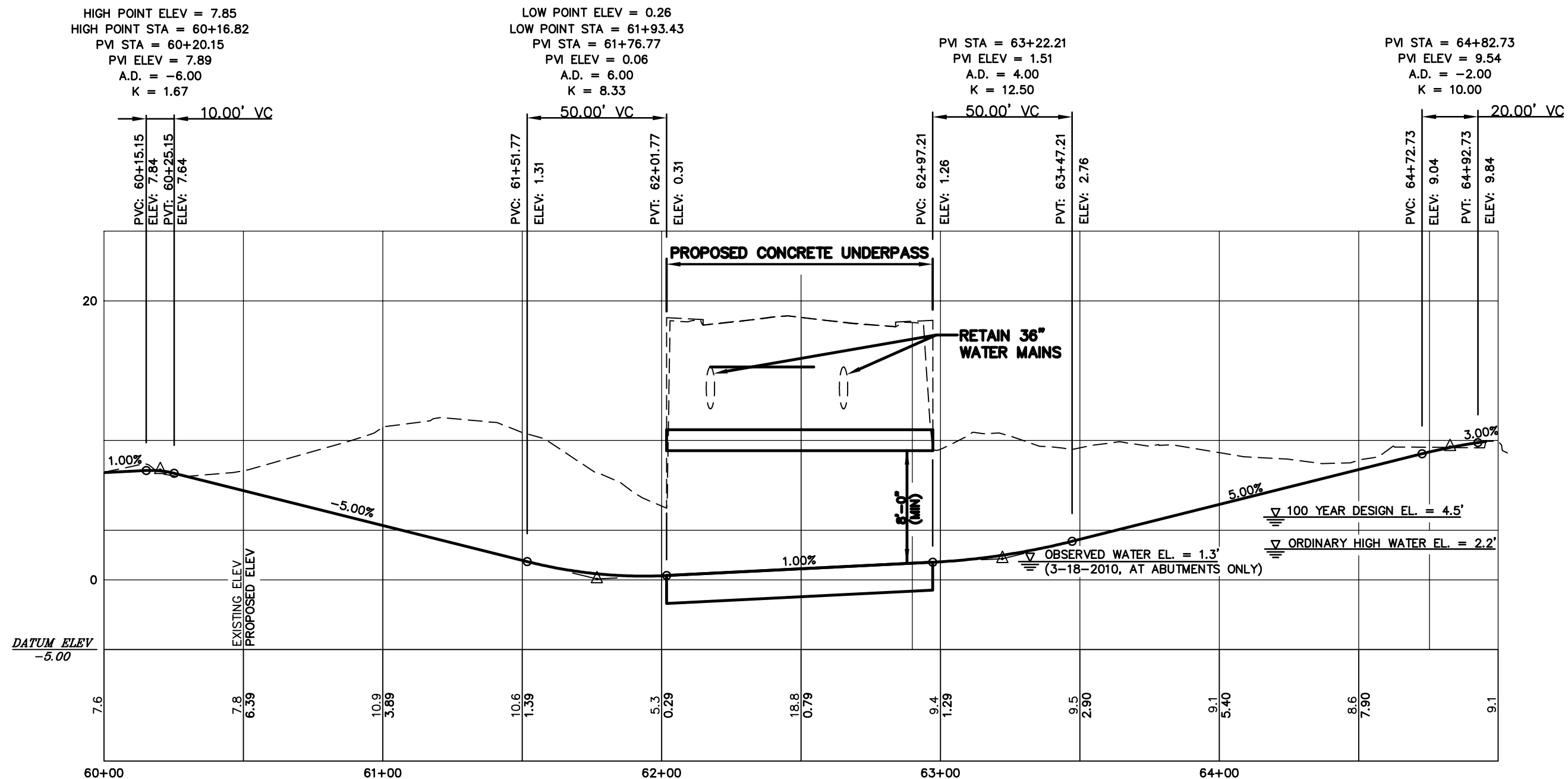
UNDERPASS FEASIBILITY STUDY  
 ALTERNATIVE 3A  
 UNDERPASS PROFILE-BOSTON

APRIL 2010

FIGURE NO. 7







FAY, SPOFFORD & THORNDIKE  
 5 BURLINGTON WOODS  
 BURLINGTON, MA 01803



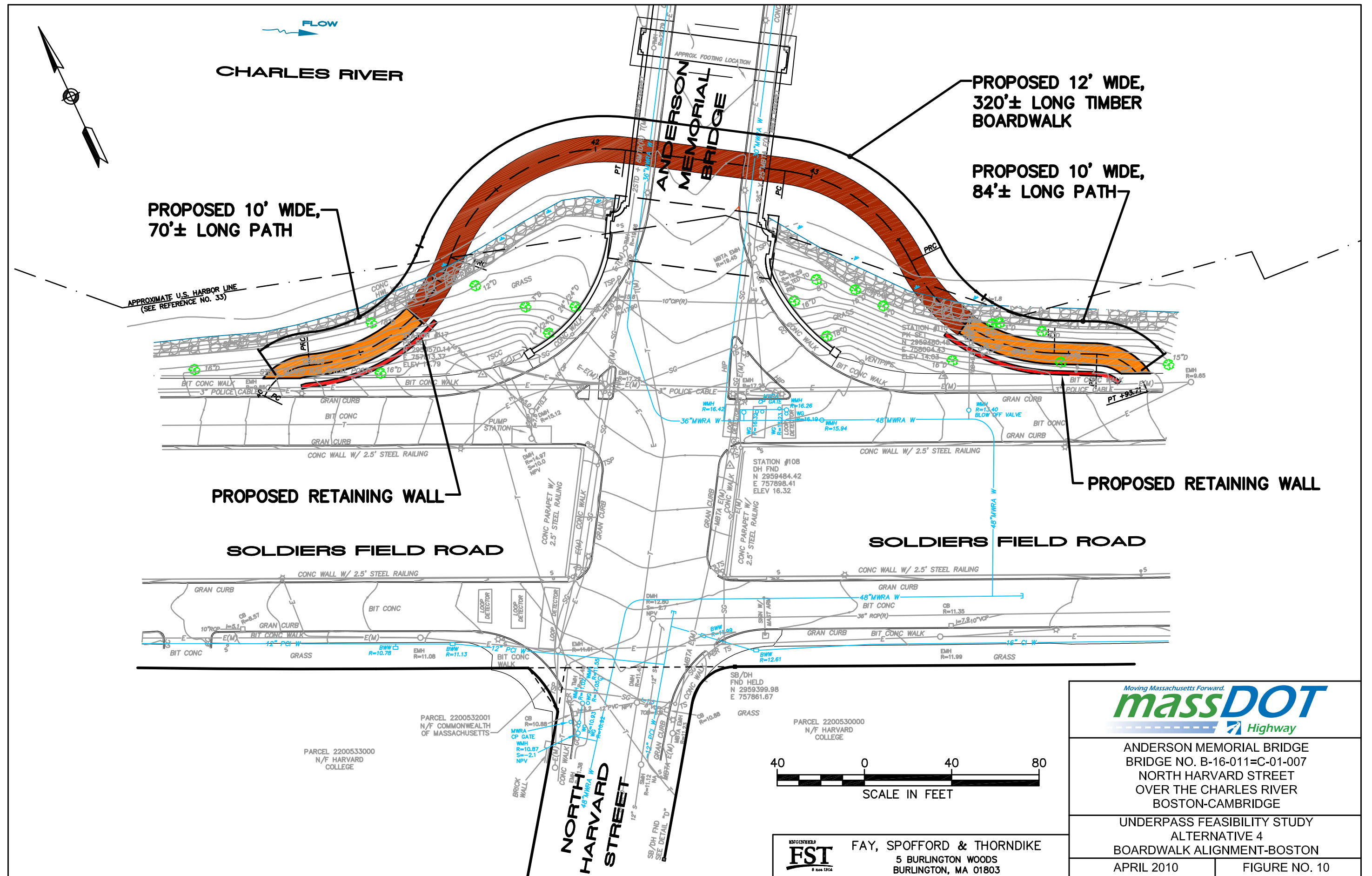
ANDERSON MEMORIAL BRIDGE  
 BRIDGE NO. B-16-011=C-01-007  
 NORTH HARVARD STREET  
 OVER THE CHARLES RIVER  
 BOSTON-CAMBRIDGE

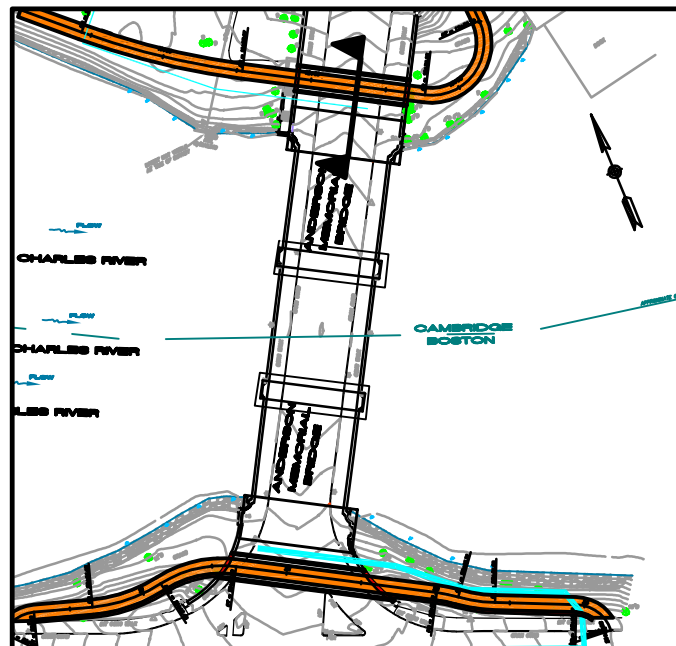
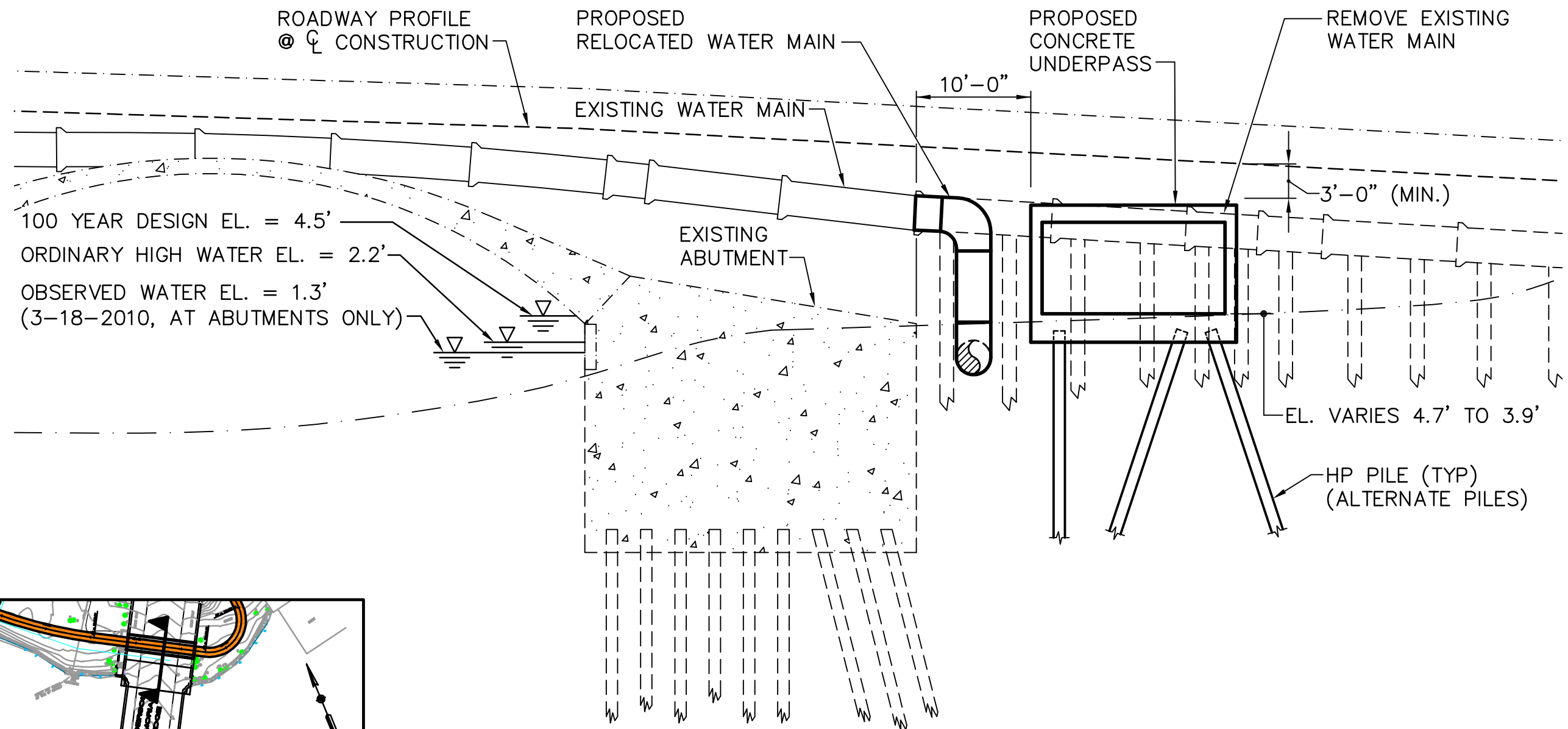
UNDERPASS FEASIBILITY STUDY  
 ALTERNATIVE 3B  
 UNDERPASS PROFILE-BOSTON

APRIL 2010

FIGURE NO. 9







## ALTERNATIVE 1A UNDERPASS WITH RELOCATED WATER MAIN – CAMBRIDGE

SCALE: 1"=10'



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

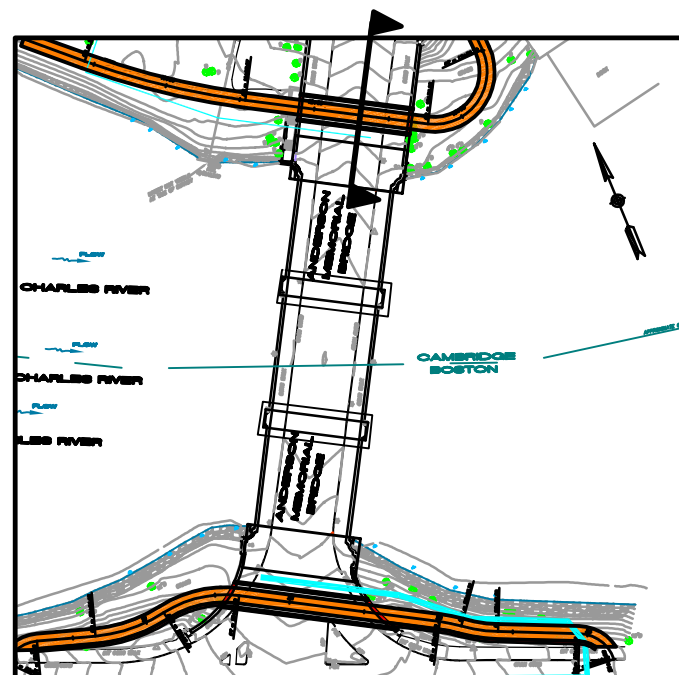
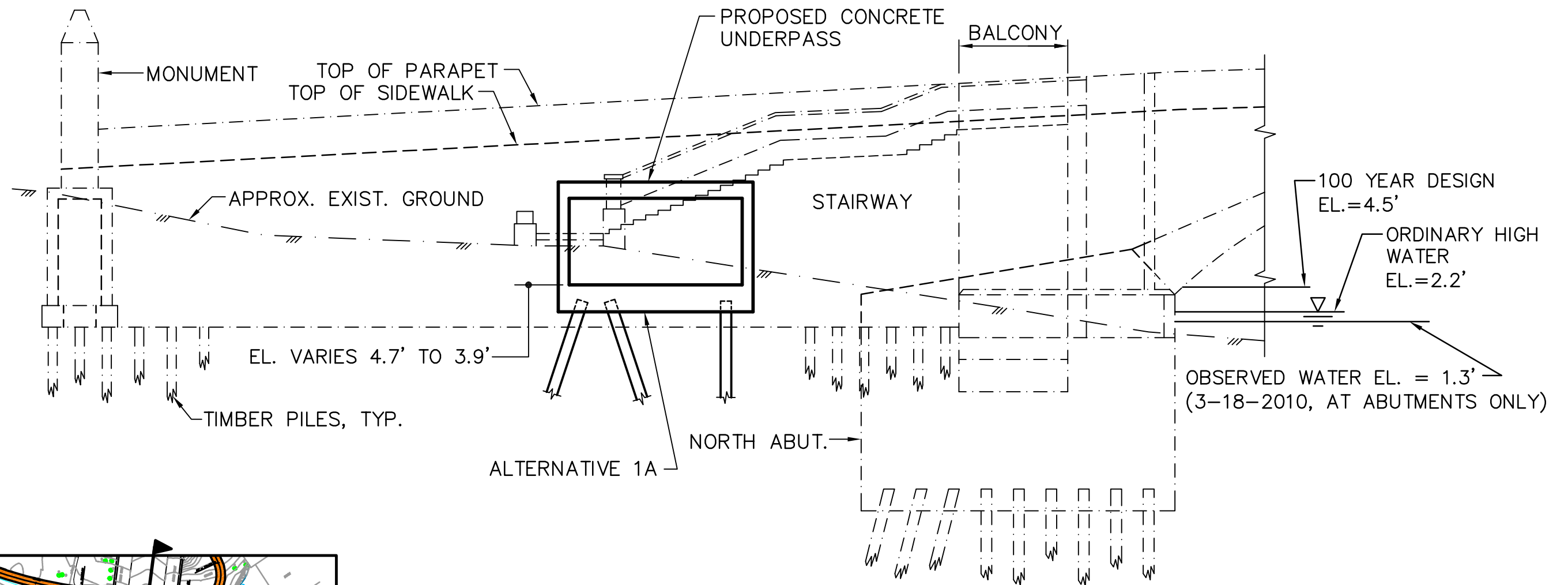


ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 1A  
LONGITUDINAL SECTION

APRIL 2010

FIGURE NO. 11



# **ALTERNATIVE 1A UNDERPASS AT NORTHWEST STAIRS WEST ELEVATION — CAMBRIDGE** SCALE: 1"=10'



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

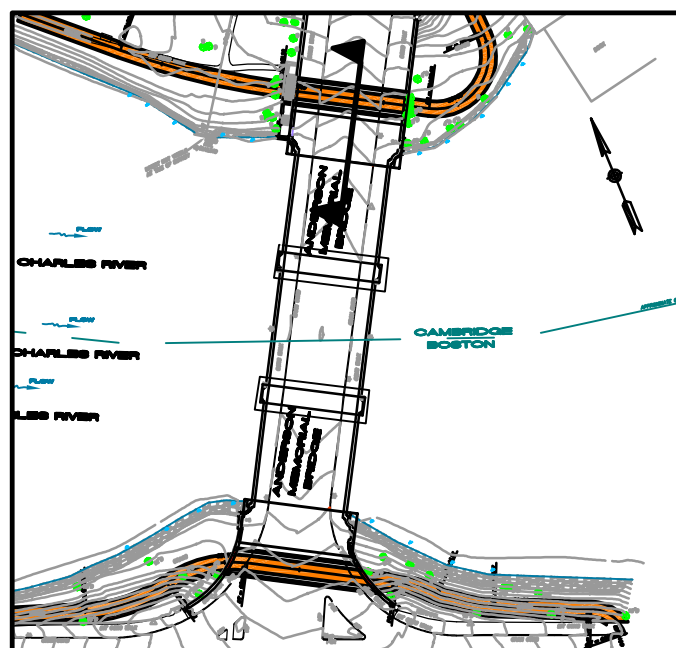
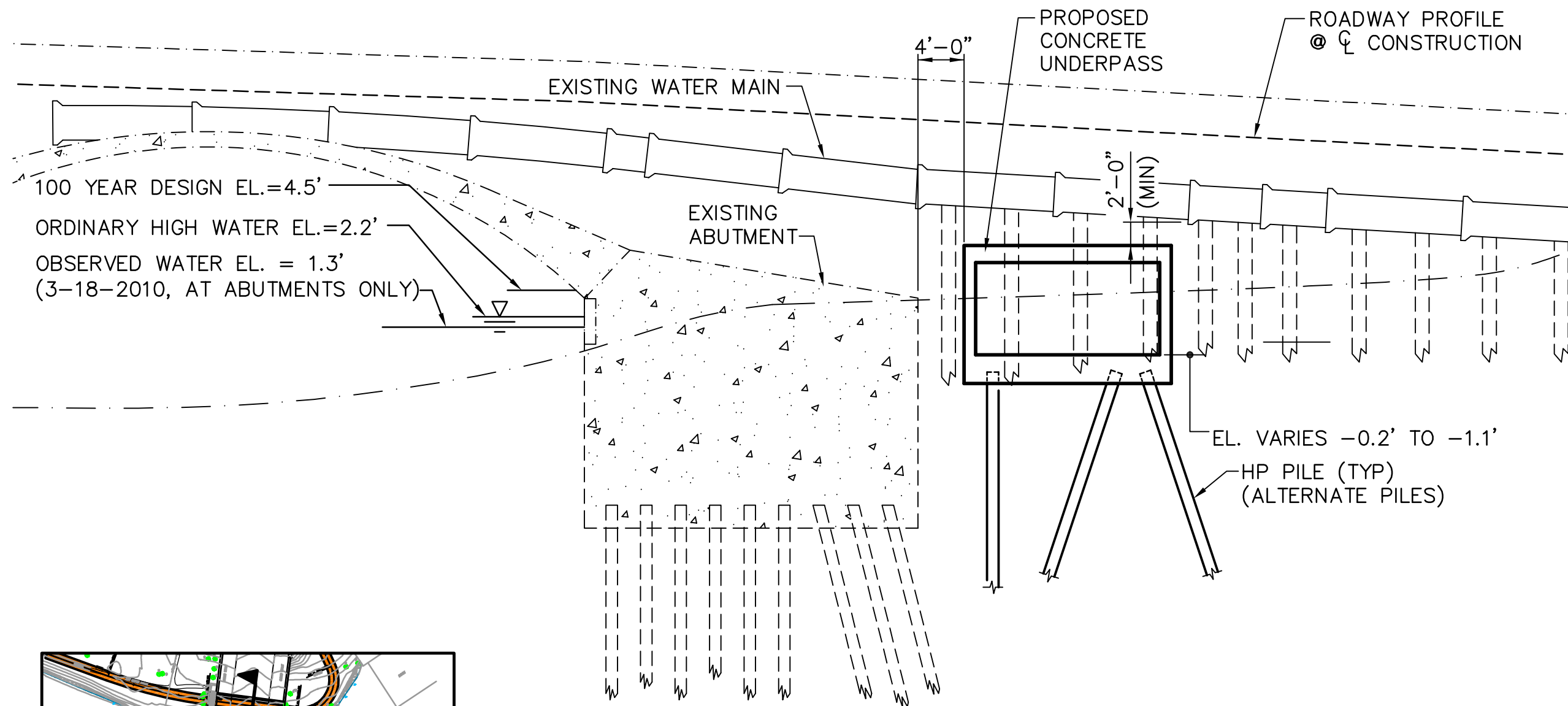


ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 1A  
ELEVATION

APRIL 2010

FIGURE NO. 12



# **ALTERNATIVE 1B UNDERPASS BELOW WATER MAIN – CAMBRIDGE** SCALE: 1"=10'



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803



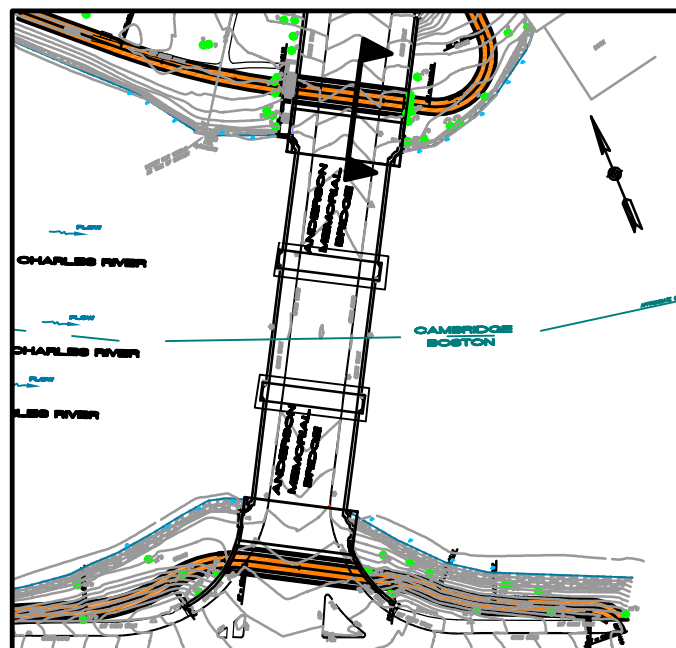
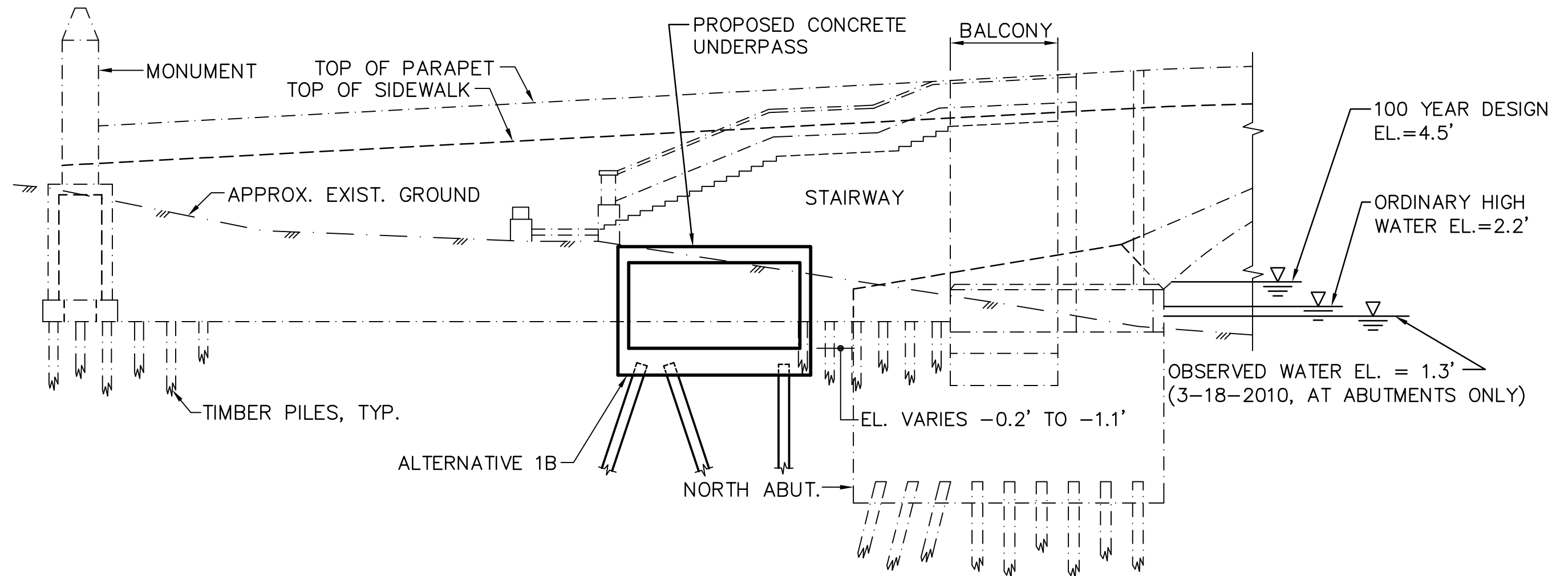
ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 1B  
LONGITUDINAL SECTION

APRIL 2010

FIGURE NO. 13





**ALTERNATIVE 1B UNDERPASS AT  
NORTHWEST STAIRS  
WEST ELEVATION – CAMBRIDGE**  
SCALE: 1"=10'



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

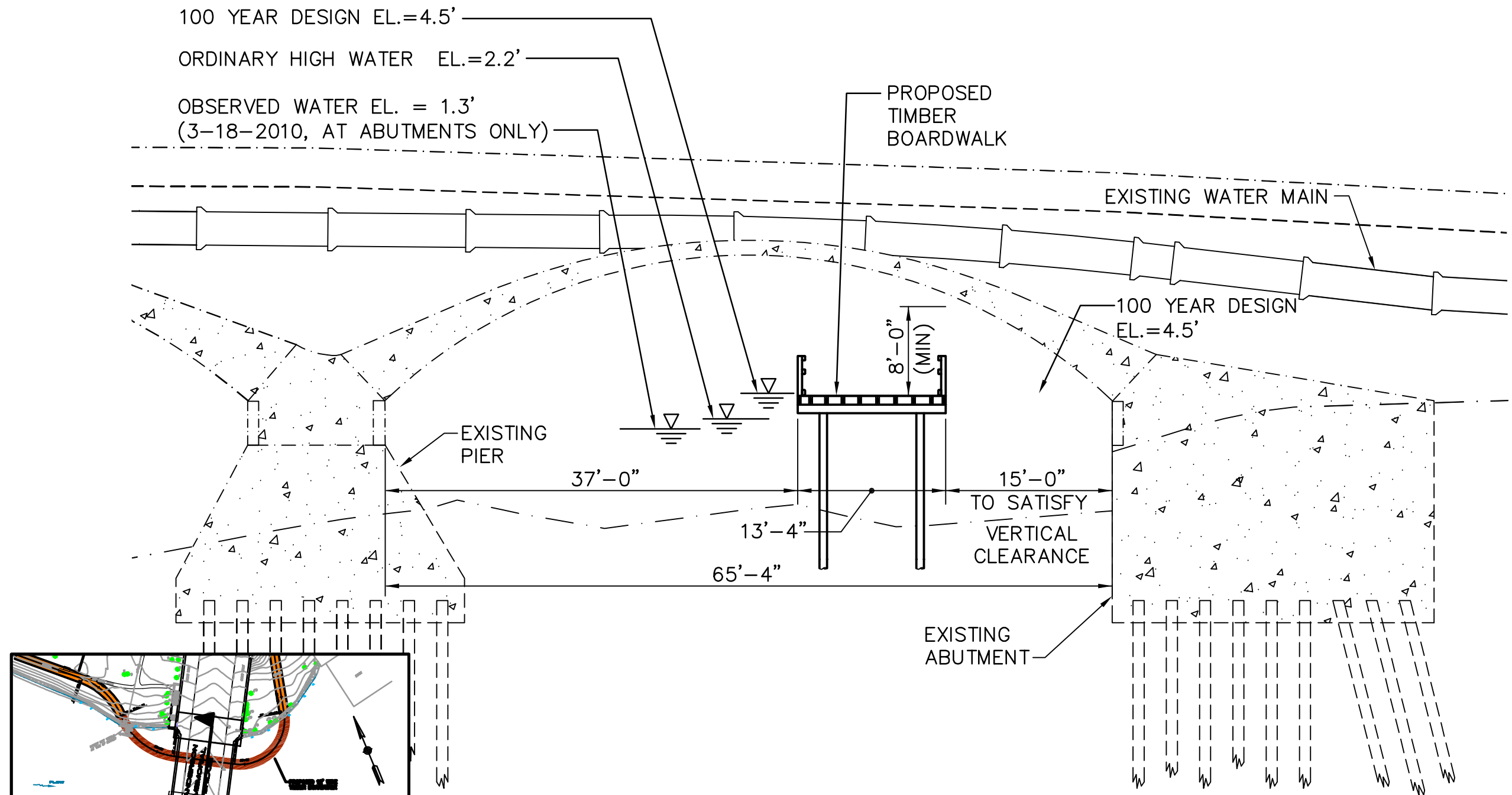


ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 1B  
ELEVATION

APRIL 2010

FIGURE NO. 14

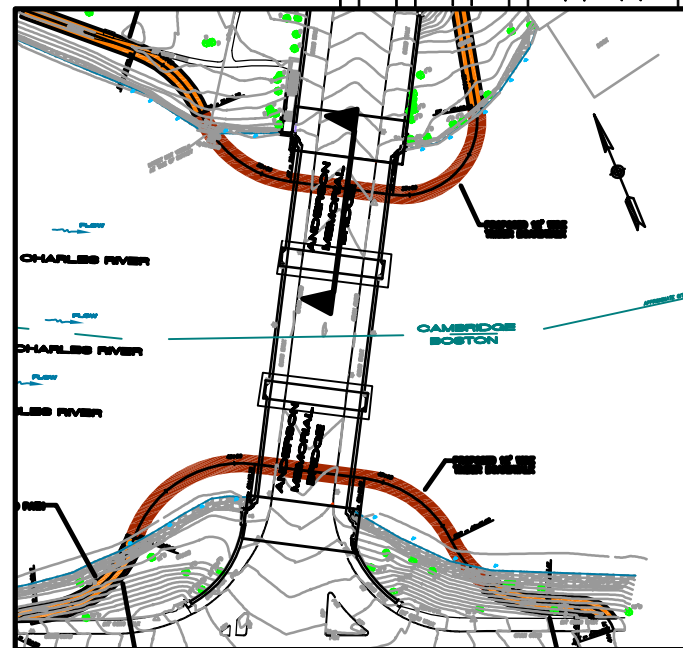


## ALTERNATIVE 2 BOARDWALK –CAMBRIDGE

SCALE: 1"=10'

### NOTE:

ALTERNATIVE 2 AT CAMBRIDGE  
APPROACH IS SHOWN. ALTERNATIVE  
4 AT BOSTON APPROACH IS  
SIMILAR AND OPPOSITE IMAGE.



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

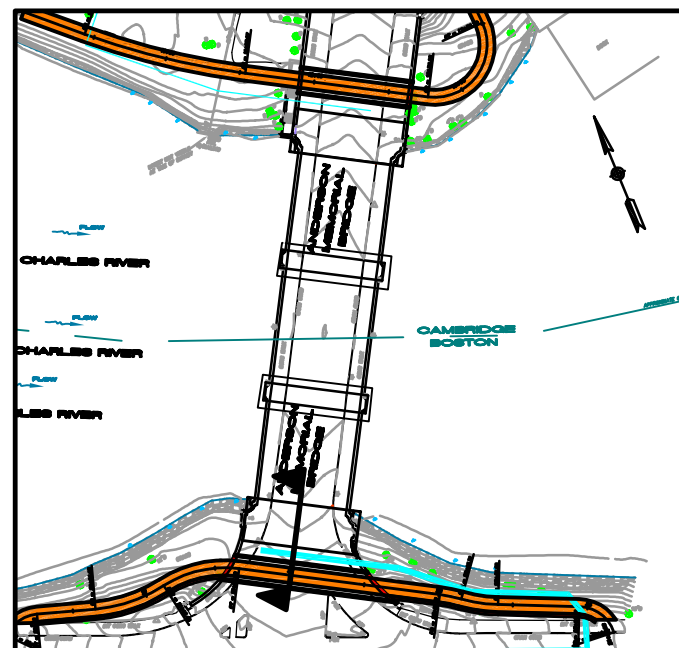
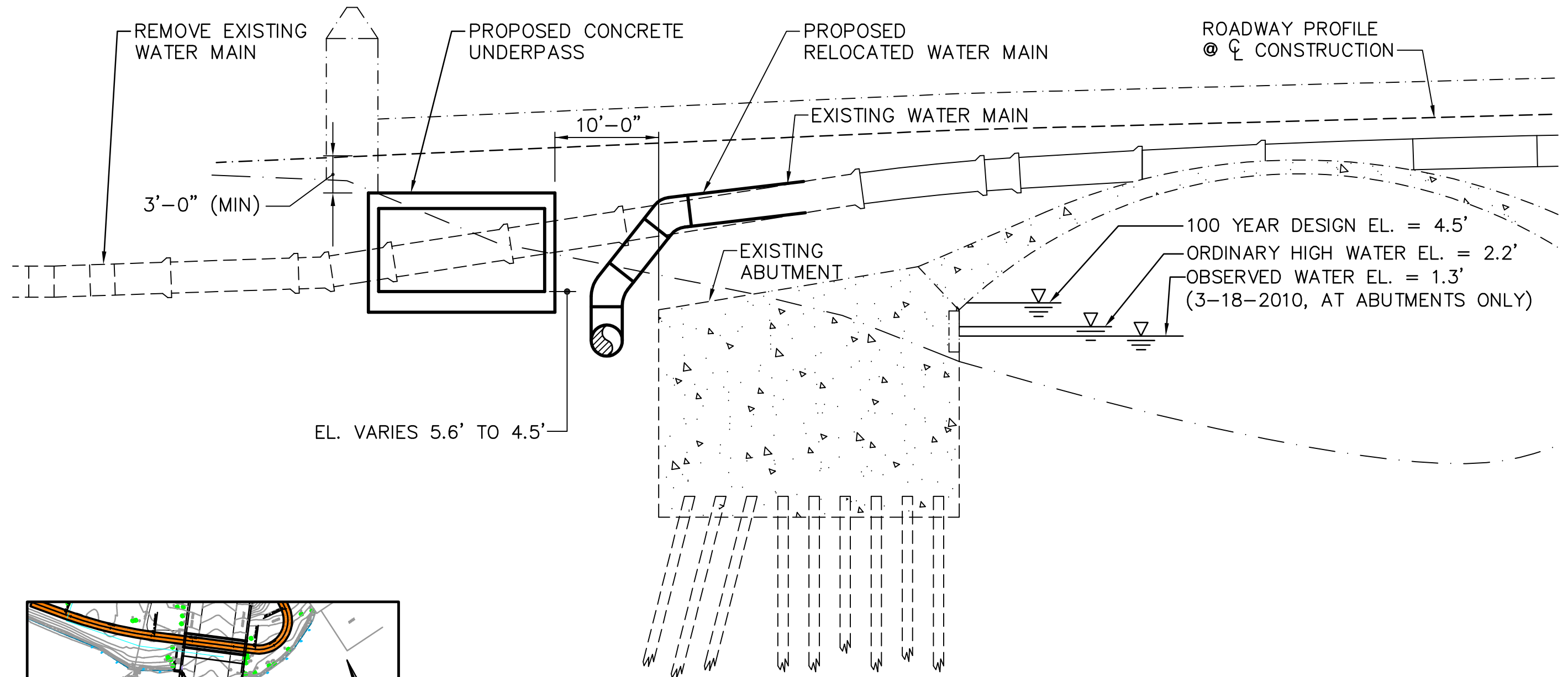


ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 2  
LONGITUDINAL SECTION

APRIL 2010

FIGURE NO. 15



# **ALTERNATIVE 3A UNDERPASS WITH RELOCATED WATER MAIN – BOSTON** SCALE: 1"=10'



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

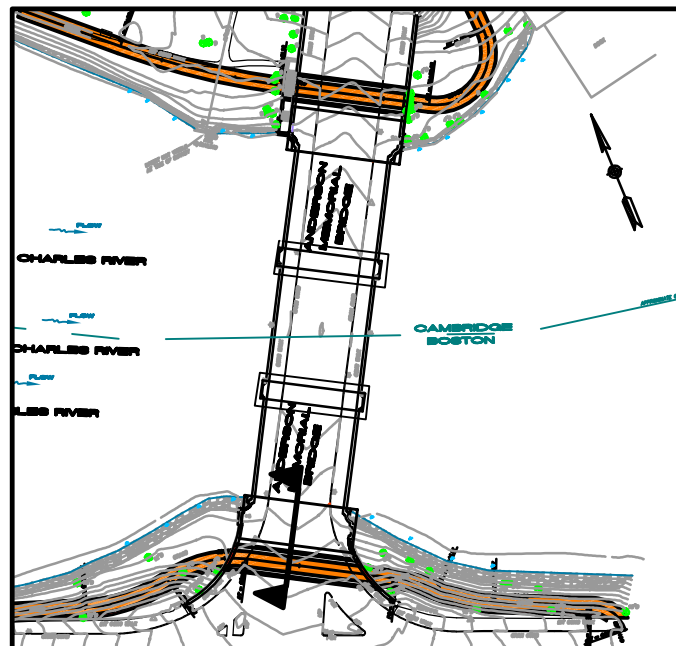
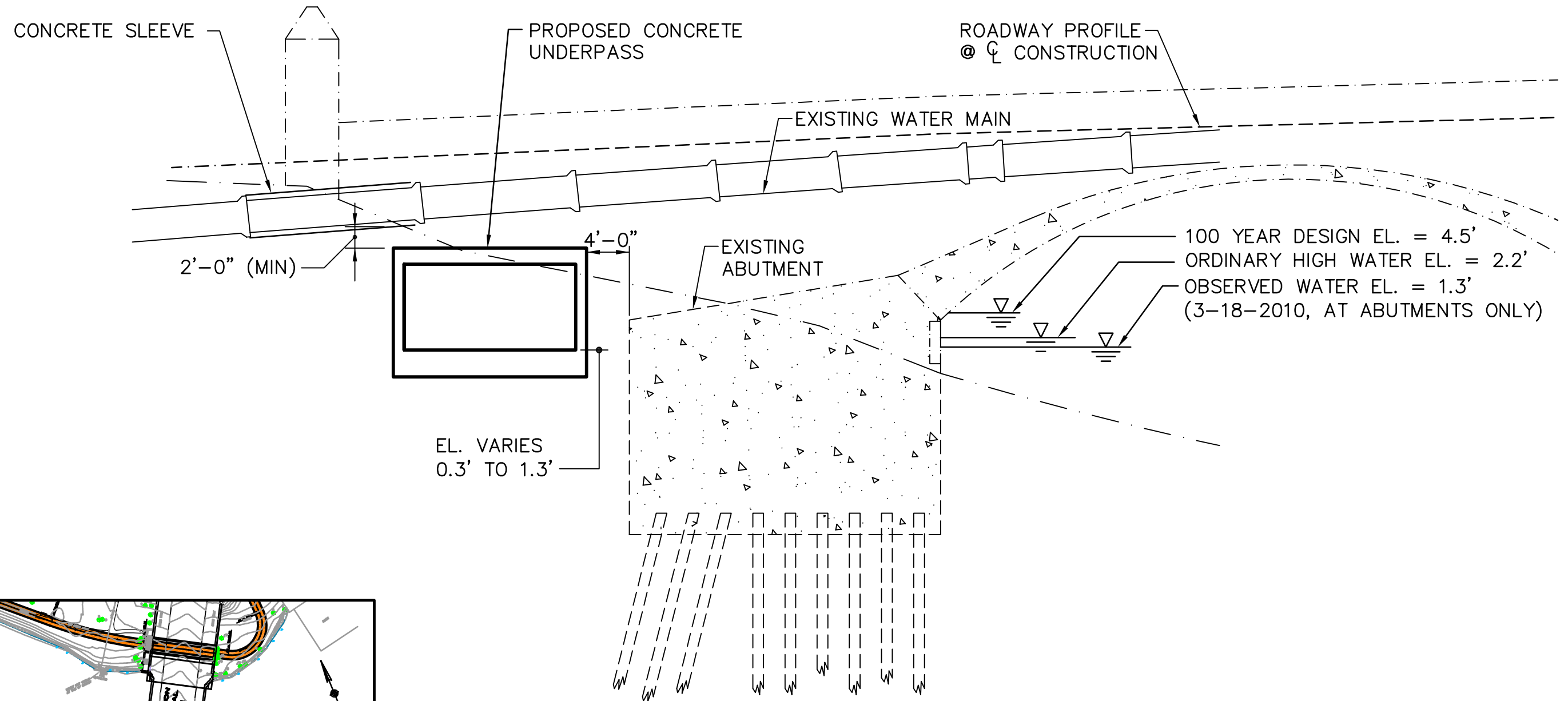


ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 3A  
LONGITUDINAL SECTION

APRIL 2010

FIGURE NO. 16



## **ALTERNATIVE 3B UNDERPASS BELOW WATER MAIN – BOSTON** SCALE: 1"=10'



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803



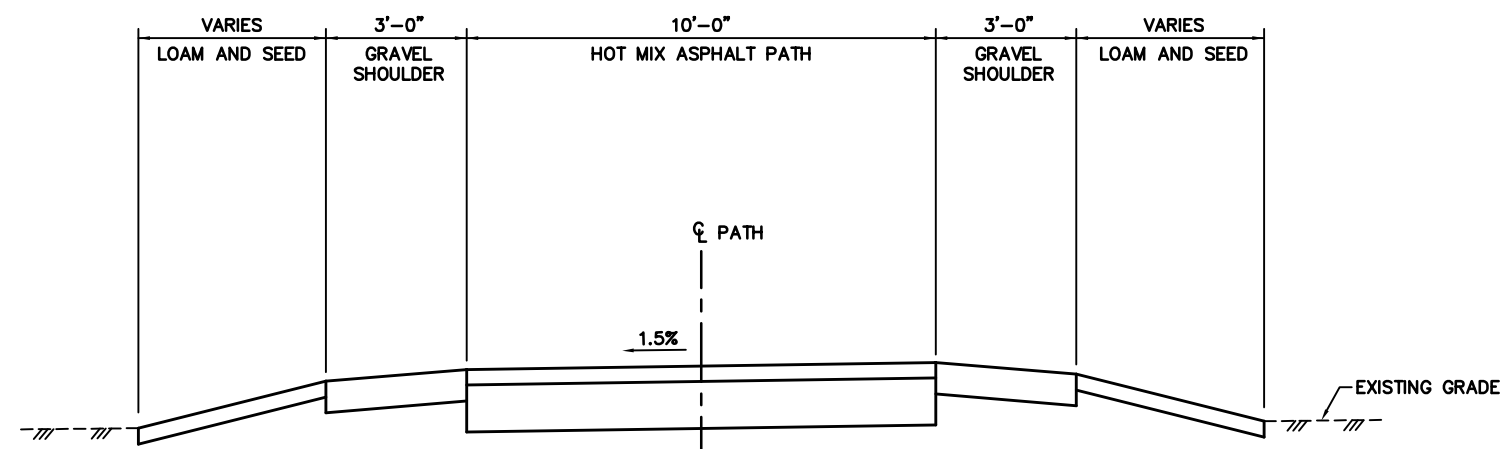
ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
ALTERNATIVE 3B  
LONGITUDINAL SECTION

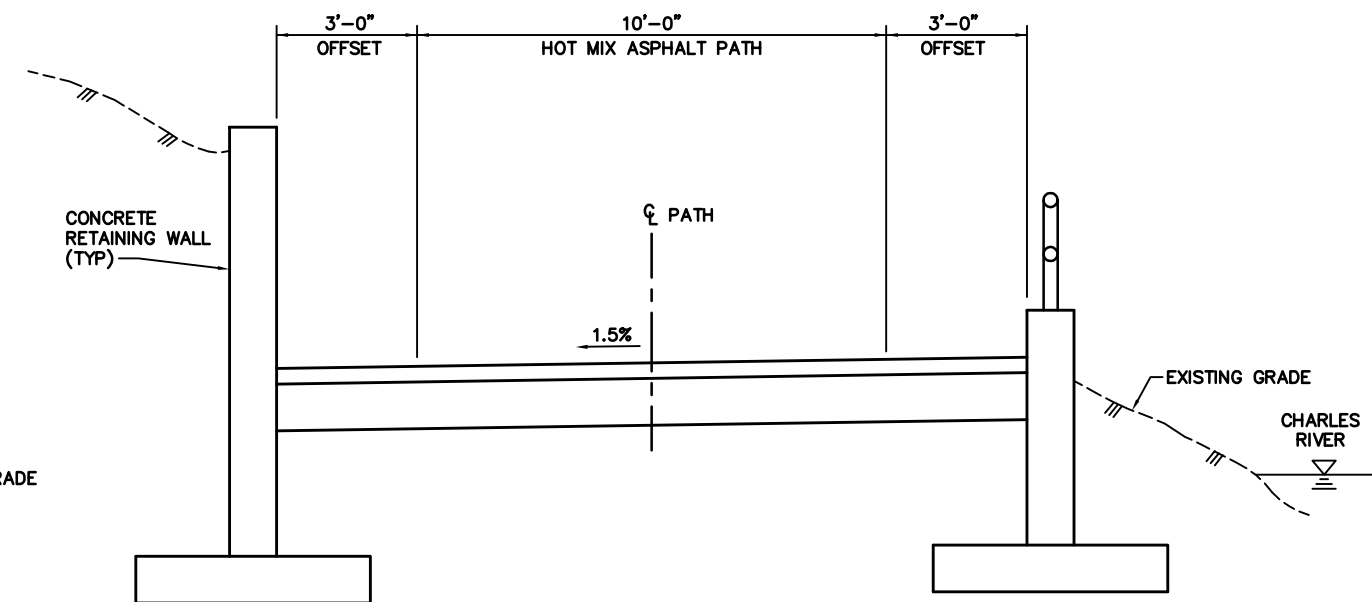
APRIL 2010

FIGURE NO. 17

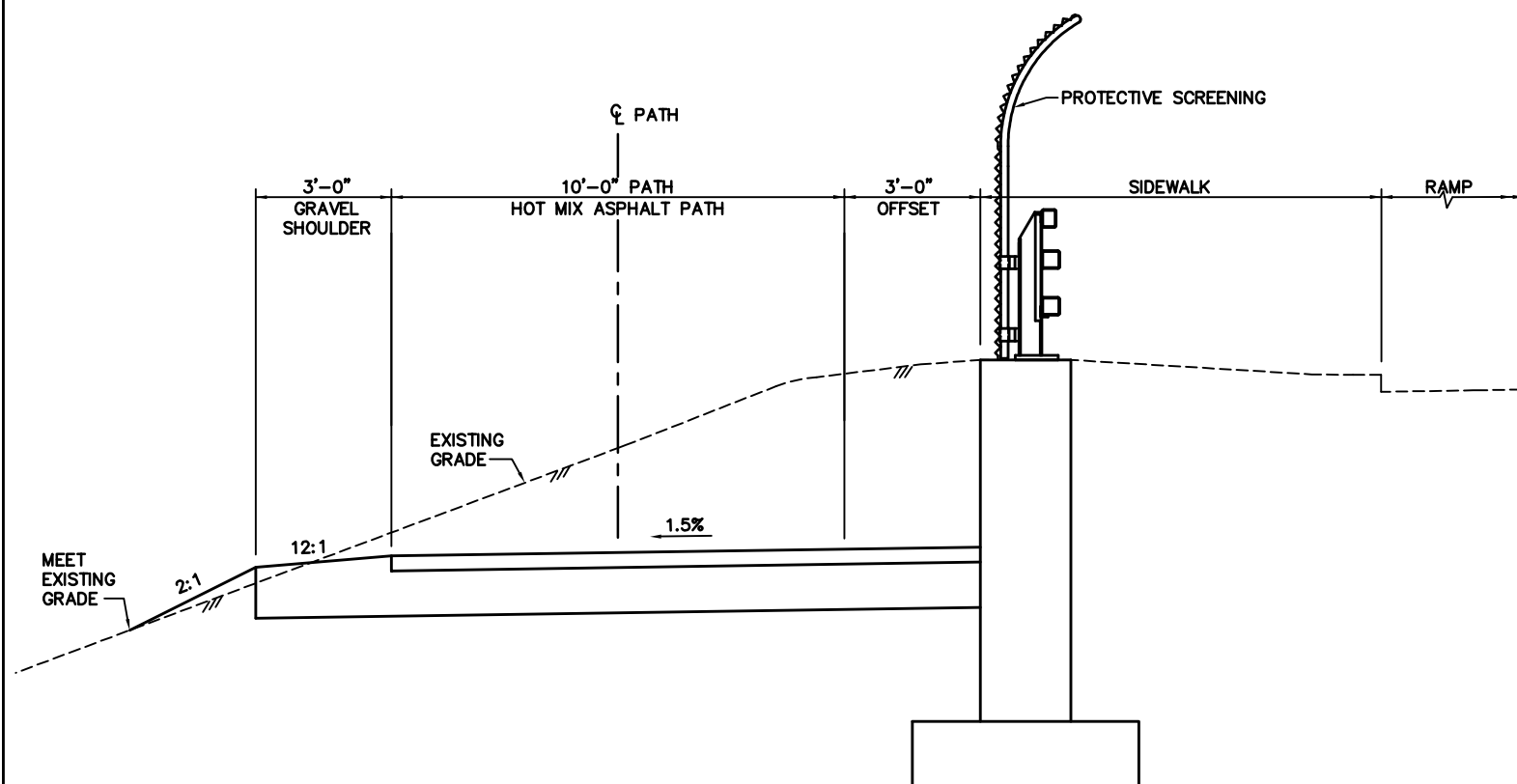




**MULTI-USE PATH FILL SECTION**  
SCALE: 1/4"=1'-0"



**MULTI-USE PATH CUT SECTION**  
SCALE: 1/4"=1'-0"



**MULTI-USE PATH WITH RETAINING WALL**  
SCALE: 1/4"=1'-0"



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

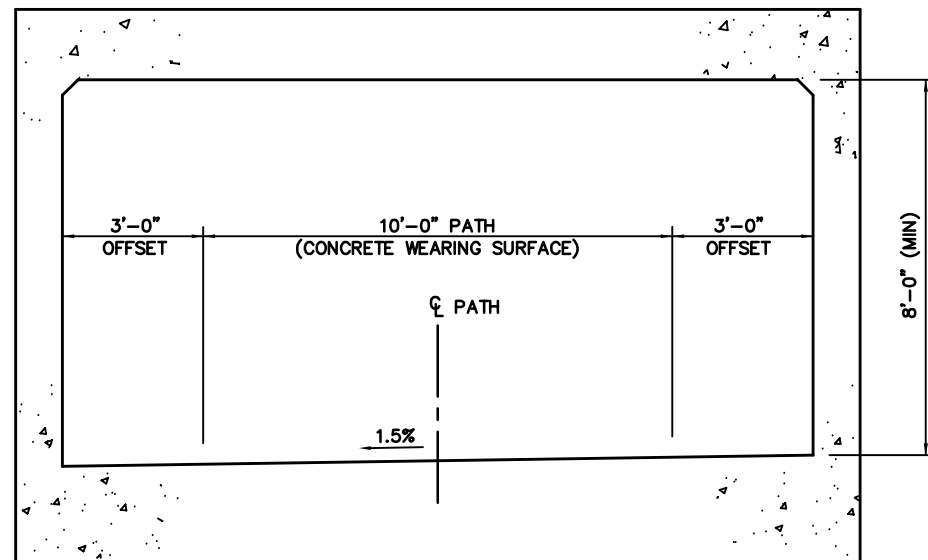


ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

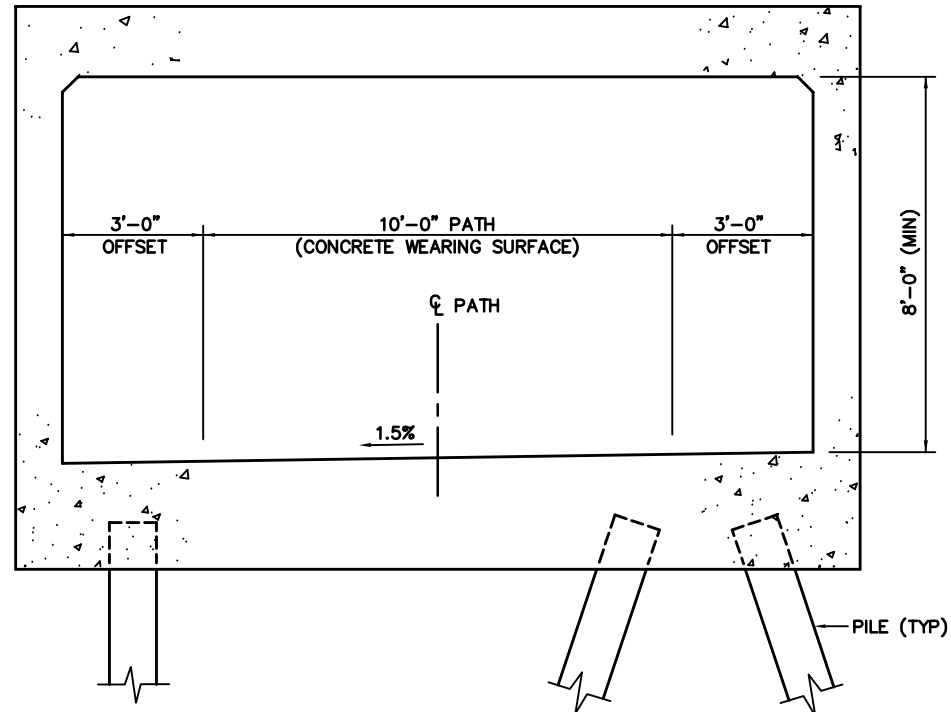
UNDERPASS FEASIBILITY STUDY  
TYPICAL SECTIONS - I

APRIL 2010

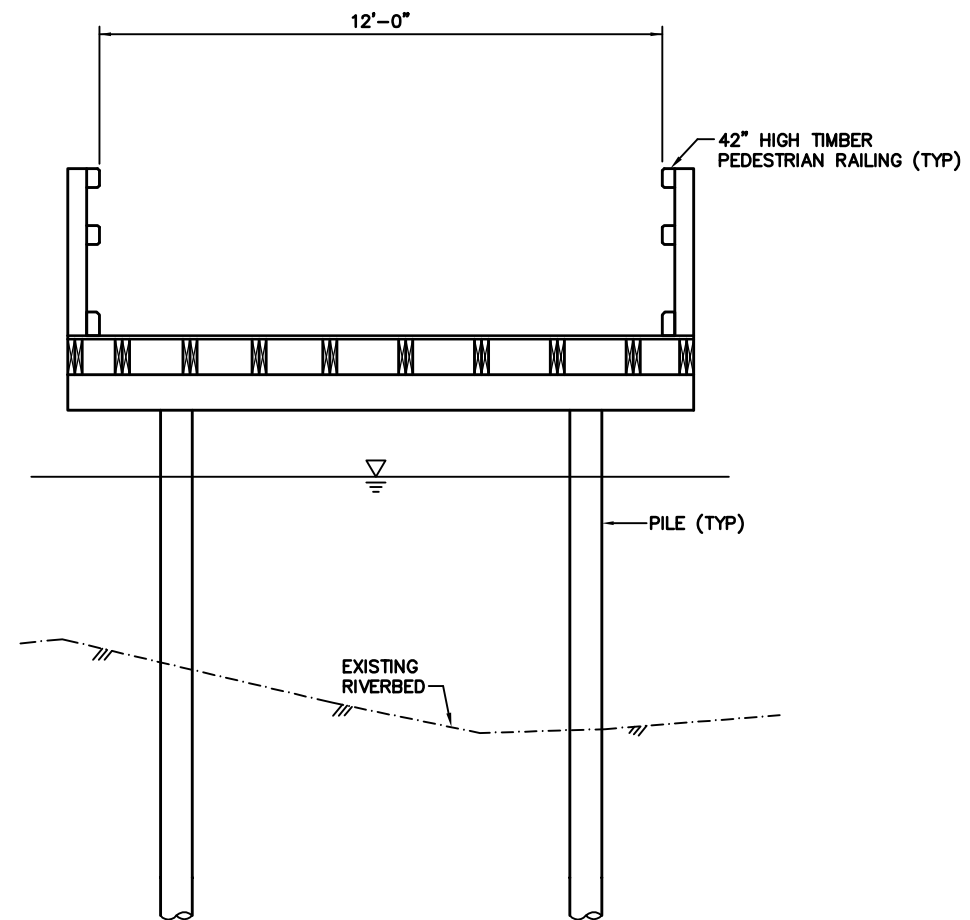
FIGURE NO. 18



**TYPICAL CONCRETE UNDERPASS SECTION – BOSTON**  
SCALE: 1/4"=1'-0"



**TYPICAL CONCRETE UNDERPASS SECTION – CAMBRIDGE**  
SCALE: 1/4"=1'-0"



**TYPICAL TIMBER BOARDWALK SECTION**  
SCALE: 1/4"=1'-0"



ANDERSON MEMORIAL BRIDGE  
BRIDGE NO. B-16-011=C-01-007  
NORTH HARVARD STREET  
OVER THE CHARLES RIVER  
BOSTON-CAMBRIDGE

UNDERPASS FEASIBILITY STUDY  
TYPICAL SECTIONS - II

APRIL 2010

FIGURE NO. 19



FAY, SPOFFORD & THORNDIKE  
5 BURLINGTON WOODS  
BURLINGTON, MA 01803

## **APPENDIX C**

### **Cost Estimate**

BIKE / PEDESTRIAN UNDERPASS FEASIBILITY STUDY  
ANDERSON MEMORIAL BRIDGE, PROECT No. 605517  
BOSTON / CAMBRIDGE  
ESTIMATE OF QUANTITIES  
PREPARED BY: FAY, SPOFFORD & THORNDIKE  
SEPTEMBER 2, 2010

R:\VQ-061 Larz Anderson\Pedestrian Study\Documents\Underpass Feasibility Study\FINAL Underpass Feasibility Study Report\_09-02-2010\Cost Estimate\Final\_Estimate\_09-02-2010.xls]Summary

ALT	ALTERNATIVE DESCRIPTION	TOTAL ESTIMATED CONSTRUCTION COST:	ANNUAL MAINT COST (2010 Values)
1A	Alternative 1A - Cambridge - Relocate Water Main with Concrete Underpass above Water Table	\$2,400,000.00	\$24,000.00
1B	Alternative 1B - Cambridge Side - Concrete Underpass <b>BELOW</b> Water Main	\$2,335,000.00	\$26,000.00
2	Alternative 2 - Cambridge Side - Boardwalk under North Arch	\$1,170,000.00	\$25,000.00
3A	Alternative 3A - Boston Side - Relocate Water Main with Concrete Underpass above Water Table	\$2,850,000.00	\$24,000.00
3B	Alternative 3B - Boston Side - Concrete Underpass <b>BELOW</b> Water Main	\$2,945,000.00	\$26,000.00
4	Alternative 4 - Boston Side - Boardwalk under South Arch with Retaining Walls	\$1,760,000.00	\$25,000.00

ALTERNATIVE 1A - CAMBRIDGE  
 CONCRETE UNDERPASS (RELOCATE MWRA WATER MAINS)

R:\VQ-061 Larz Anderson\Pedestrian Study\Documents\Underpass Feasibility Study\FINAL Underpass Feasibility Study Report\_09-02-2010\Cost Estimate\Final Estimate\_09-02-2010.xls\Summary

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
<u>BITUMINOUS PATH CONSTRUCTION</u>				
EXCAVATION	CY	650	\$30.00	\$19,500.00
HOT MIX ASPHALT	TON	150	\$100.00	\$15,000.00
GRAVEL BORROW	CY	400	\$30.00	\$12,000.00
<u>UTILITIES</u>				
MWRA WATER MAIN RELOCATION (NEW 48")	FT	385	\$1,200.00	\$462,000.00
MWRA WATER MAIN RELOCATION (NEW 36")	FT	40	\$820.00	\$32,800.00
OTHER UTILITIES	LS	1	\$20,000.00	\$20,000.00
<u>STRUCTURAL</u>				
ABUTMENT BRACING & MONITORING DURING TUNNEL EXCAVATION	LS	1	\$25,000.00	\$25,000.00
SUPPORT OF EXCAVATION	SF	1,300	\$50.00	\$65,000.00
RETAINING WALL EXCAVATION	CY	600	\$42.00	\$25,200.00
STEEL HP PILES	FT	700	\$200.00	\$140,000.00
4000 PSI CONCRETE - CONCRETE UNDERPASS	CY	260	\$1,200.00	\$312,000.00
4000 PSI CONCRETE - CONCRETE WINGWALLS / RETAINING WALLS	CY	150	\$800.00	\$120,000.00
REINFORCING STEEL - CONCRETE UNDERPASS	LB	26,000	\$3.50	\$91,000.00
REINFORCING STEEL - CONCRETE WINGWALLS / RETAINING WALLS	LB	15,000	\$3.50	\$52,500.00
FLEXIBLE WATERPROOFING MEMBRANE	SY	530	\$150.00	\$79,500.00
SUMP AND DRAINAGE SYSTEM	LS	1	\$130,000.00	\$130,000.00
BRIDGE RAILING TYPE S3-TL4	FT			\$0.00
BOARDWALK (WALKWAY SUPERSTRUCTURE AND PILE BENTS)	SF			\$0.00
BOARDWALK (MINI PILES)	FT			\$0.00
BOARDWALK (MOBILIZATION / SILT CONTROLS / BARGE)	LS			\$0.00
<u>LANDSCAPING/LIGHTING</u>				
LIGHTING	LS	1	\$15,000.00	\$15,000.00
LANDSCAPING AND AMENITIES	LS	1	\$100,000.00	\$100,000.00
ESTIMATED POLICE ALLOWANCE	LS	1	\$100,000.00	\$100,000.00
<b>SUBTOTAL:</b>				\$1,816,500.00
Construction Contingency (20%) :				\$363,300.00
<b>TOTAL ESTIMATED CONSTRUCTION COST:</b>				\$2,179,800.00
MassDOT Construction Administration Contingency (10%):				\$217,980.00
<b>TOTAL ESTIMATED PROJECT COST:</b>				<b>\$2,397,780.00</b>
<b>Round up</b>				<b>\$2,398,000.00</b>
<b>SAY</b>				<b>\$2,400,000.00</b>

**ESTIMATE MAINTENANCE COST**

<i>Snow Removal</i>	<i>Unit</i>	<i>#</i>	<i>Unit Cost</i>	
	Ea	10	\$500.00	\$5,000.00
<i>Lighting</i>	LS	1	\$2,000.00	\$2,000.00
<i>Landscaping Say 2 times/month over 8 months</i>	Ea	16	\$500.00	\$8,000.00
<i>Maintain Drainage, sweeping, cleaning - say twice a year</i>	Ea	2	\$1,000.00	\$2,000.00
<i>SUMP &amp; PUMPING SYSTEM</i>	LS	1	\$2,000.00	\$2,000.00
<i>Misc (repairs, inspections, etc.)</i>	LS	1	\$5,000.00	\$5,000.00
<b>TOTAL</b>				<b>\$24,000.00</b>
<b>SAY</b>				<b>\$24,000.00</b>

ALTERNATIVE 1B - CAMBRIDGE  
CONCRETE UNDERPASS (MAINTAIN MWRA WATER MAINS)

R:\VQ-061 Larz Anderson\Pedestrian Study\Documents\Underpass Feasibility Study\FINAL Underpass Feasibility Study Report\_09-02-2010\Cost Estimate\[Final\_Estimate\_09-02-2010.xls]Summary

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
BITUMINOUS PATH CONSTRUCTION				
EXCAVATION	CY	1,000	\$30.00	\$30,000.00
HOT MIX ASPHALT	TON	150	\$100.00	\$15,000.00
GRAVEL BORROW	CY	400	\$30.00	\$12,000.00
UTILITIES				
MWRA WATER MAIN RELOCATION (NEW 48")	FT			\$0.00
MWRA WATER MAIN RELOCATION (NEW 36")	FT			\$0.00
OTHER UTILITIES	LS	1	\$20,000.00	\$20,000.00
STRUCTURAL				
ABUTMENT BRACING & MONITORING DURING TUNNEL EXCAVATION	LS	1	\$50,000.00	\$50,000.00
SUPPORT OF EXCAVATION	SF	3,000	\$50.00	\$150,000.00
RETAINING WALL EXCAVATION	CY	1,250	\$42.00	\$52,500.00
STEEL HP PILES	FT	900	\$200.00	\$180,000.00
4000 PSI CONCRETE - CONCRETE UNDERPASS	CY	260	\$1,200.00	\$312,000.00
4000 PSI CONCRETE - CONCRETE WINGWALLS / RETAINING WALLS	CY	350	\$800.00	\$280,000.00
REINFORCING STEEL - CONCRETE UNDERPASS	LB	26,000	\$3.50	\$91,000.00
REINFORCING STEEL - CONCRETE WINGWALLS / RETAINING WALLS	LB	35,000	\$3.50	\$122,500.00
FLEXIBLE WATERPROOFING MEMBRANE	SY	530	\$150.00	\$79,500.00
SUMP AND DRAINAGE SYSTEM	LS	1	\$160,000.00	\$160,000.00
BRIDGE RAILING TYPE S3-TL4	FT			\$0.00
BOARDWALK (WALKWAY SUPERSTRUCTURE AND PILE BENTS)	SF			\$0.00
BOARDWALK (MINI PILES)	FT			\$0.00
BOARDWALK (MOBILIZATION / SILT CONTROLS / BARGE)	LS			\$0.00
LANDSCAPING/LIGHTING				
LIGHTING	LS	1	\$15,000.00	\$15,000.00
LANDSCAPING AND AMENITIES	LS	1	\$100,000.00	\$100,000.00
ESTIMATED POLICE ALLOWANCE				
	LS	1	\$100,000.00	\$100,000.00
SUBTOTAL:				\$1,769,500.00
Construction Contingency (20%) :				\$353,900.00
TOTAL ESTIMATED CONSTRUCTION COST:				\$2,123,400.00
MassDOT Construction Administration Contingency (10%):				\$212,340.00
TOTAL ESTIMATED PROJECT COST:				\$2,335,740.00
Round up				\$2,335,800.00
SAY				\$2,335,000.00

ESTIMATE MAINTENANCE COST

Snow Removal  
Lighting  
Landscaping Say 2 times/month over 8 months  
Maintain Drainage, sweeping, cleaning - say twice a year  
SUMP & PUMPING SYSTEM  
Misc (repairs, inspections, etc.)

Unit	#	Unit Cost	
Ea	10	\$500.00	\$5,000.00
LS	1	\$2,000.00	\$2,000.00
Ea	16	\$500.00	\$8,000.00
Ea	2	\$1,000.00	\$2,000.00
LS	1	\$4,000.00	\$4,000.00
LS	1	\$5,000.00	\$5,000.00
TOTAL			\$26,000.00

SAY \$26,000.00

ALTERNATIVE 2 - CAMBRIDGE  
 TIMBER BOARDWALK

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ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
<u>BITUMINOUS PATH CONSTRUCTION</u>				
EXCAVATION	CY	350	\$30.00	\$10,500.00
HOT MIX ASPHALT	TON	100	\$100.00	\$10,000.00
GRAVEL BORROW	CY	250	\$30.00	\$7,500.00
<u>UTILITIES</u>				
MWRA WATER MAIN RELOCATION (NEW 48")	FT			\$0.00
MWRA WATER MAIN RELOCATION (NEW 36")	FT			\$0.00
OTHER UTILITIES	LS	1	\$20,000.00	\$20,000.00
<u>STRUCTURAL</u>				
ABUTMENT BRACING & MONITORING DURING TUNNEL EXCAVATION	LS		\$25,000.00	\$0.00
SUPPORT OF EXCAVATION	SF		\$50.00	\$0.00
RETAINING WALL EXCAVATION	CY		\$42.00	\$0.00
STEEL HP PILES	FT		\$200.00	\$0.00
4000 PSI CONCRETE - CONCRETE UNDERPASS	CY		\$1,200.00	\$0.00
4000 PSI CONCRETE - CONCRETE WINGWALLS / RETAINING WALLS	CY		\$800.00	\$0.00
REINFORCING STEEL - CONCRETE UNDERPASS	LB		\$3.50	\$0.00
REINFORCING STEEL - CONCRETE WINGWALLS / RETAINING WALLS	LB		\$3.50	\$0.00
FLEXIBLE WATERPROOFING MEMBRANE	SY		\$150.00	\$0.00
SUMP AND DRAINAGE SYSTEM	LS		\$130,000.00	\$0.00
BRIDGE RAILING TYPE S3-TL4	FT			\$0.00
BOARDWALK (WALKWAY SUPERSTRUCTURE AND PILE BENTS)	SF	4,000	\$70.00	\$280,000.00
BOARDWALK (MINI PILES)	FT	2,430	\$110.00	\$267,300.00
BOARDWALK (MOBILIZATION / SILT CONTROLS / BARGE)	LS	1	\$75,000.00	\$75,000.00
<u>LANDSCAPING/LIGHTING</u>				
LIGHTING	LS	1	\$15,000.00	\$15,000.00
LANDSCAPING AND AMENITIES	LS	1	\$100,000.00	\$100,000.00
ESTIMATED POLICE ALLOWANCE	LS	1	\$100,000.00	\$100,000.00
<b>SUBTOTAL:</b>				\$885,300.00
Construction Contingency (20%) :				\$177,060.00
<b>TOTAL ESTIMATED CONSTRUCTION COST:</b>				\$1,062,360.00
MassDOT Construction Administration Contingency (10%):				\$106,236.00
<b>TOTAL ESTIMATED PROJECT COST:</b>				<b>\$1,168,596.00</b>
<b>Round up</b>				<b>\$1,169,000.00</b>
<b>SAY</b>				<b>\$1,170,000.00</b>

**ESTIMATE MAINTENANCE COST**

	Unit	#	Unit Cost	
Snow Removal	Ea	10	\$500.00	\$5,000.00
Lighting	LS	1	\$2,000.00	\$2,000.00
Landscaping Say 2 times/month over 8 months	Ea	16	\$500.00	\$8,000.00
Maintain Drainage, sweeping, cleaning - say twice a year	Ea	2	\$1,000.00	\$2,000.00
Misc (repairs, inspections, etc.)	LS	1	\$8,000.00	\$8,000.00
		<b>TOTAL</b>	<b>\$25,000.00</b>	
				<b>SAY \$25,000.00</b>

ALTERNATIVE 3A - BOSTON  
 CONCRETE UNDERPASS (RELOCATE MWRA WATER MAINS)

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ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
<u>BITUMINOUS PATH CONSTRUCTION</u>				
EXCAVATION	CY	1,200	\$30.00	\$36,000.00
HOT MIX ASPHALT	TON	75	\$100.00	\$7,500.00
GRAVEL BORROW	CY	200	\$30.00	\$6,000.00
<u>UTILITIES</u>				
MWRA WATER MAIN RELOCATION (NEW 48")	FT	270	\$1,200.00	\$324,000.00
MWRA WATER MAIN RELOCATION (NEW 36")	FT	50	\$820.00	\$41,000.00
OTHER UTILITIES	LS	1	\$20,000.00	\$20,000.00
<u>STRUCTURAL</u>				
ABUTMENT BRACING & MONITORING DURING TUNNEL EXCAVATION	LS	1	\$25,000.00	\$25,000.00
SUPPORT OF EXCAVATION	SF	3,500	\$50.00	\$175,000.00
RETAINING WALL EXCAVATION	CY	650	\$42.00	\$27,300.00
STEEL HP PILES	FT	575	\$200.00	\$115,000.00
4000 PSI CONCRETE - CONCRETE UNDERPASS	CY	300	\$1,200.00	\$360,000.00
4000 PSI CONCRETE - CONCRETE WINGWALLS / RETAINING WALLS	CY	300	\$800.00	\$240,000.00
REINFORCING STEEL - CONCRETE UNDERPASS	LB	30,000	\$3.50	\$105,000.00
REINFORCING STEEL - CONCRETE WINGWALLS / RETAINING WALLS	LB	30,000	\$3.50	\$105,000.00
FLEXIBLE WATERPROOFING MEMBRANE	SY	650	\$150.00	\$97,500.00
SUMP AND DRAINAGE SYSTEM	LS	1	\$130,000.00	\$130,000.00
BRIDGE RAILING TYPE S3-TL4	FT	310	\$415.00	\$128,650.00
BOARDWALK (WALKWAY SUPERSTRUCTURE AND PILE BENTS)	SF			\$0.00
BOARDWALK (MINI PILES)				
BOARDWALK (MOBILIZATION / SILT CONTROLS / BARGE)				
<u>LANDSCAPING/LIGHTING</u>				
LIGHTING	LS	1	\$15,000.00	\$15,000.00
LANDSCAPING AND AMENITIES	LS	1	\$100,000.00	\$100,000.00
ESTIMATED POLICE ALLOWANCE	LS	1	\$100,000.00	\$100,000.00
<b>SUBTOTAL:</b>				<b>\$2,157,950.00</b>
Construction Contingency (20%) :				\$431,590.00
<b>TOTAL ESTIMATED CONSTRUCTION COST:</b>				<b>\$2,589,540.00</b>
MassDOT Construction Administration Contingency (10%):				\$258,954.00
<b>TOTAL ESTIMATED PROJECT COST:</b>				<b>\$2,848,494.00</b>
<b>Round up</b>				<b>\$2,849,000.00</b>
<b>SAY</b>				<b>\$2,850,000.00</b>
ANNUAL Maintenance (lighting, electrical, landscaping, snowremoval, drainage system. (same as Alt 1A)				\$24,000.00



ALTERNATIVE 3B - BOSTON  
 CONCRETE UNDERPASS (MAINTAIN MWRA WATER MAINS)

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ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
<u>BITUMINOUS PATH CONSTRUCTION</u>				
EXCAVATION	CY	2,000	\$30.00	\$60,000.00
HOT MIX ASPHALT	TON	75	\$100.00	\$7,500.00
GRAVEL BORROW	CY	200	\$30.00	\$6,000.00
<u>UTILITIES</u>				
MWRA WATER MAIN RELOCATION (NEW 48")	FT			\$0.00
MWRA WATER MAIN RELOCATION (NEW 36")	FT			\$0.00
OTHER UTILITIES	LS	1	\$20,000.00	\$20,000.00
<u>STRUCTURAL</u>				
ABUTMENT BRACING & MONITORING DURING TUNNEL EXCAVATION	LS	1	\$50,000.00	\$50,000.00
SUPPORT OF EXCAVATION	SF	6,000	\$50.00	\$300,000.00
RETAINING WALL EXCAVATION	CY	1,100	\$42.00	\$46,200.00
STEEL HP PILES	FT	750	\$200.00	\$150,000.00
4000 PSI CONCRETE - CONCRETE UNDERPASS	CY	300	\$1,200.00	\$360,000.00
4000 PSI CONCRETE - CONCRETE WINGWALLS / RETAINING WALLS	CY	430	\$800.00	\$344,000.00
REINFORCING STEEL - CONCRETE UNDERPASS	LB	30,000	\$3.50	\$105,000.00
REINFORCING STEEL - CONCRETE WINGWALLS / RETAINING WALLS	LB	43,000	\$3.50	\$150,500.00
FLEXIBLE WATERPROOFING MEMBRANE	SY	650	\$150.00	\$97,500.00
SUMP AND DRAINAGE SYSTEM	LS	1	\$160,000.00	\$160,000.00
BRIDGE RAILING TYPE S3-TL4	FT	380	\$415.00	\$157,700.00
BOARDWALK (WALKWAY SUPERSTRUCTURE AND PILE BENTS)	SF			\$0.00
BOARDWALK (MINI PILES)				
BOARDWALK (MOBILIZATION / SILT CONTROLS / BARGE)				
<u>LANDSCAPING/LIGHTING</u>				
LIGHTING	LS	1	\$15,000.00	\$15,000.00
LANDSCAPING AND AMENITIES	LS	1	\$100,000.00	\$100,000.00
ESTIMATED POLICE ALLOWANCE	LS	1	\$100,000.00	\$100,000.00
<b>SUBTOTAL:</b>				<b>\$2,229,400.00</b>
Construction Contingency (20%) :				\$445,880.00
<b>TOTAL ESTIMATED CONSTRUCTION COST:</b>				<b>\$2,675,280.00</b>
MassDOT Construction Administration Contingency (10%):				\$267,528.00
<b>TOTAL ESTIMATED PROJECT COST:</b>				<b>\$2,942,808.00</b>
<b>Round up</b>				<b>\$2,943,000.00</b>
<b>SAY</b>				<b>\$2,945,000.00</b>
ANNUAL Maintenance (lighting, electrical, landscaping, snowremoval, drainage system. (same as Alt 1B)				\$26,000.00

ALTERNATIVE 4 - BOSTON  
 TIMBER BOARDWALK

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ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
<u>BITUMINOUS PATH CONSTRUCTION</u>				
EXCAVATION	CY	250	\$30.00	\$7,500.00
HOT MIX ASPHALT	TON	60	\$100.00	\$6,000.00
GRAVEL BORROW	CY	150	\$30.00	\$4,500.00
<u>UTILITIES</u>				
MWRA WATER MAIN RELOCATION (NEW 48")	FT			\$0.00
MWRA WATER MAIN RELOCATION (NEW 36")	FT			\$0.00
OTHER UTILITIES	LS	1	\$20,000.00	\$20,000.00
<u>STRUCTURAL</u>				
ABUTMENT BRACING & MONITORING DURING TUNNEL EXCAVATION	LS		\$50,000.00	\$0.00
SUPPORT OF EXCAVATION	SF	300	\$50.00	\$15,000.00
RETAINING WALL EXCAVATION	CY	650	\$42.00	\$27,300.00
STEEL HP PILES	FT		\$200.00	\$0.00
4000 PSI CONCRETE - CONCRETE UNDERPASS	CY		\$1,200.00	\$0.00
4000 PSI CONCRETE - CONCRETE RETAINING WALLS	CY	250	\$800.00	\$200,000.00
REINFORCING STEEL - CONCRETE UNDERPASS	LB		\$3.50	\$0.00
REINFORCING STEEL - CONCRETE RETAINING WALLS	LB	25,000	\$3.50	\$87,500.00
FLEXIBLE WATERPROOFING MEMBRANE	SY		\$150.00	\$0.00
SUMP AND DRAINAGE SYSTEM	LS		\$160,000.00	\$0.00
BRIDGE RAILING TYPE S3-TL4	FT	190	\$415.00	\$78,850.00
BOARDWALK (WALKWAY SUPERSTRUCTURE AND PILE BENTS)	SF	4,420	\$70.00	\$309,400.00
BOARDWALK (MINI PILES)	FT	2,610	\$110.00	\$287,100.00
BOARDWALK (MOBILIZATION / SILT CONTROLS / BARGE)	LS	1	\$75,000.00	\$75,000.00
<u>LANDSCAPING/LIGHTING</u>				
LIGHTING	LS	1	\$15,000.00	\$15,000.00
LANDSCAPING AND AMENITIES	LS	1	\$100,000.00	\$100,000.00
ESTIMATED POLICE ALLOWANCE	LS	1	\$100,000.00	\$100,000.00
<b>SUBTOTAL:</b>				\$1,333,150.00
Construction Contingency (20%) :				\$266,630.00
<b>TOTAL ESTIMATED CONSTRUCTION COST:</b>				\$1,599,780.00
MassDOT Construction Administration Contingency (10%):				\$159,978.00
<b>TOTAL ESTIMATED PROJECT COST:</b>				<b>\$1,759,758.00</b>
<b>Round up</b>				<b>\$1,760,000.00</b>
<b>SAY</b>				<b>\$1,760,000.00</b>
ANNUAL Maintenance (lighting, electrical, landscaping, snowremoval, drainage system. (same as Alt 2)				\$25,000.00

## **APPENDIX D**

### **Comparison Table**

***Bike and Pedestrian Underpass Feasibility Study*****Summary of Evaluated Elements***Note: all data are preliminary and reflect 10% design information.*

	<b>At-Grade Crossing/Rehabilitation Project</b>	<b>Tunnel Underpass</b>	<b>Boardwalk</b>
<b>Element Evaluated</b>			
<b>Feasibility</b>			
	The proposed rehabilitation of the Anderson Memorial Bridge will include improvements at the signalized roadway crossings for pedestrians, as well as bicycle and vehicular traffic.	Feasible, but have adverse impacts to the historical integrity of the bridge and the surrounding area, with associated risks to the project schedule.	Feasible, but have adverse impacts to the historical integrity of the bridge and the surrounding area, with associated risks to the project schedule
<b>Ped/ Bike/ Connectivity</b>			
	The proposed rehabilitation of the Anderson Memorial Bridge will include improvements at the signalized roadway crossings for pedestrians, as well as bicycle and vehicular traffic.	Provides un-interrupted pedestrian and bicycle crossing.	Provides un-interrupted pedestrian and bicycle crossing.
<b>Utility Impacts</b>			
	Negligible.	Impact to MWRA Water main can be mitigated at a cost.	Negligible.
<b>Effects on Cultural Resources</b>			
	No Averse Effect is anticipated.	Adverse Effect is anticipated from each Boston and Cambridge underpasses.	Adverse Effect from each Boston and Cambridge boardwalks.

***Bike and Pedestrian Underpass Feasibility Study***

	<b>At-Grade Crossing/Rehabilitation Project</b>	<b>Tunnel Underpass</b>	<b>Boardwalk</b>
<b>Element Evaluated</b>			
<b>Security and Surveillance</b>			
	No negative impact due to general visibility of crossings.	Hidden. Need for added police/security patrols and/or surveillance of the access and paths by the responsible agency or city.	Hidden. Need for added police & security patrols and/or surveillance of the access and paths by the responsible agency or city.
<b>Impact to Navigation &amp; Rowers</b>			
	No negative impact.	No negative impact.	Negative impact. Restricts boat navigation and use by rowers at the End Channels.
<b>Schedule</b>			
	No negative impact.	Negative impact to design and permitting schedule.	Negative impact to design and permitting schedule.